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In8 International Association of Computer Science in Sport (IACSS) Conference (3., 31st of july to 3rd of august 2016, Brasilia - Brazil)


First Edition
Copyright and official year of printing: Brasilia, July 31st to August 3rd, 2016.
The International Association of Computer Science in Sport Conference 2016 took place between July 31 – August 3, 2016 in Brasilia, BR. The aim of the conference was to promote the inter-disciplinary field of sport science and computer science in order to face challenging problems in sports and exercise sciences, supported by formal models, analytical approaches and computational support. It also favored the exchanges between researchers of both fields and promote academic cooperation. The conference covered the following topics:

- Computer Vision
- Robotics
- Image Processing
- Virtual-reality
- Modelling and Simulation
- Data acquisition and Analysis
- Decision Support
We had 26 accepted papers after a peer-review process by the Program Committee. Five keynote speakers, Jürgen Perl, Martin Lames, Dean Oliver, Junior Barrera and Gilbert Fellingham covered distinct features of the field, also extending contributions to other fields related to quantitative methods in sports.

We would like to thank all the participants for coming to Brasilia. We also thank the Program Committee members, the reviewers and the invited speakers for their contributions to make the event a great success.

Leonardo Lamas, Proceedings Editor
Tiago Russomanno, Proceedings Co-Editor

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Professor Junior Barrera | University of Sao Paulo, Brazil
Professor Jürgen Perl | University of Mainz, Germany
Professor Martin Lames | Technical University of Munich, Germany
Professor Gilbert Fellingham | Brigham Young University, USA
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COMPUTER VISION AND ARTIFICIAL INTELLIGENCE IN SPORTS
This study describes an approach to quantification of attacking and defensive performance in football. Our procedure determines a quantitative representation of the probability of a goal being scored for every point in time at which a player is in possession of the ball – we refer to this as dangerousity. The calculation is based on the spatial constellation of the player and the ball, and comprises of the four components Zone, Control, Pressure and Density. We use these metrics to analyse individual actions in a match, to describe passages of play and to characterise the performance and efficiency of teams over the season.

KEYWORDS: Performance Analysis, Performance Indicator, Football, Spatial Configuration, Success Criterion
INTRODUCTION

The availability of virtually all-encompassing positional data in professional football presents new challenges for the way in which that data is analysed and interpreted. Recent years have seen an increasing number of publications that try to derive intelligent indicators from the raw data and describe tactical structures (Lucey et al., 2015; Grunz et al., 2012). This paper suggests a solution to the question how success in football can be quantified. Until now, there has been no convincing procedure available by means of which the value of a piece of dribbling can be compared with a pass. If a coach wants to know whether a change in defensive midfield has led to greater stability in defence, he has not so far had any quantitative criterion that would allow such an assessment. Our approach use a quantitative representation for the probability of a goal, which we describe as dangerousity.

In this abstract we describe the quantification of dangerousity, show the results of the evaluation and propose some options for their application.

QUANTIFYING DANGEROUSITY

Dangerousity (DANGER) is present for every moment in which a player is in possession of the ball. DANGER is based on the four components ZONE, CONTROL, PRESSURE and DENSITY. ZONE represents the danger of a goal being scored from the position of the IBA-player, CONTROL stands for the extent to which the player can implement his tactical intention on the basis of the ball dynamics, PRESSURE represents the opportunity of the defending team to prevent the IBA-player from completing an action with the ball and DENSITY is the chance of being able to defend the ball after the action. ZONE and CONTROL increment DANGER, whereas PRESSURE and DENSITY decrement DANGER.

\[
DANGER(t) = ZONE(t) \cdot \left(1 - \frac{1 - CONTROL(t) + PRESSURE(t) + DENSITY(t)}{k_t}\right)
\]

These individual components give the DANGER for a point in time t as the product of ZONE and a linear combination of CONTROL, PRESSURE and DENSITY(t). The model constant \(k_t\) quantifies the extent to which these three figures reduce the value for ZONE. It is selected in such a way that ZONE is reduced by a maximum of a factor of 0.5. As a lack of control of the ball results in a reduction in the danger, CONTROL is included as an inverse.

EVALUATION

Three experts evaluated \(n=100\) playing situations independently of one another on the basis of video recordings using a scale of 1 (little danger) to 5 (very dangerous). They had no knowledge of the underlying model, but were asked to evaluate the scenarios qualitatively in their entirety. For the statistical analysis, the situations were grouped (DANGER GROUPS) following their assessments by the majority principle and checked for differences using an ANOVA. The results show that the mean value for DANGER differed significantly between the groups (\(F=170.31, p<.01\)). All of the posthoc tests between neighbouring groups also showed significant differences (\(=.01\)). This means that scenarios that were classified as dangerous by the observers were also classified as dangerous on average by the algorithm.
Figure 1
Boxplot of DANGER. Scenarios that were classified as dangerous by the observers were also classified as dangerous on average by the algorithm.

GAME ANALYSIS
Based on dangerousity we derive other metrics for game analysis: Action Value represents the extent to which the player can make a situation more dangerous through his possession of the ball. Performance quantifies the number and quality of the attacks by a team over a period of time, while Dominance describes the difference in performance between teams. This variables can be used to evaluate individual plays, to describe efficiency, represent passages of play, or compare players and teams with one another. In particular, they can help to investigate questions relating to the influence of various playing systems or tactical group concepts on success.

REFERENCES

During the process of acquisition of motor skills, corrective instructions known as feedback, are provided by experts for athletes, these lead the athletes to an improvement of learning or improvement performance. The purpose of this study was to create an avatar to represent accurately the movement of the Hang Power Snatch (derivative of the Snatch, the most complex of Olympic weightlifting movements) in order to be used as visual feedback during the acquisition of motor skills.

**KEYWORDS:** Olympic weightlifting, computer animation, power snatch, feedback
INTRODUCTION

During the process of learning a sport, both motor and technical skills are acquired. The coaches make use of different corrective forms that consist of feedback to the trainee. Feedback is the information provided during the training that indicates the trainee the errors in their own performance (Teixeira 2006). The feedback can be intrinsic, in which the information is perceived visually or by proprioception (Winchester, Porter et al. 2009) or extrinsic also known as Augmented Feedback. Augmented feedback is related to additional or enhanced information that the subject receives (Swinnen, Lee et al. 1997, Magill 2001). About this second type, there are two types of feedback studies: the ones that provided knowledge of results and the ones that provided knowledge of performance (Rucci and Tomporowski 2010), demonstrating the latter as more effective both during the learning acquisition process as well as refinement of more complex movements (Magill and Wood 1986, Schmidt 2005)(Landin and Macdonald 1990, Kemodle and Carlton 1992). The visual feedback of the performance can be achieved by photography, filming (Sewall 1988) or verbal feedback and feedback demonstration videos (Rucci and Tomporowski 2010). The feedback demonstration videos have been used as a teaching tool in another movement of Olympic Weightlifting called Power Clean.

The Olympic weightlifting (OW) is divided into two parts: the snatch in which the athlete takes the bar above the head in one attempt and the Clean and Jerk where the head, between the two movements, the snatch is the most complex to learn. Due to the development of muscular power in athletes, especially in the lower limbs (Izquierdo, Hakkinen et al. 2002, Hori, Newton et al. 2007, Comfort, Fletcher et al. 2012, Suchomel, Beckham et al. 2014) and is their use in different sports such as improved tool athletic performance, and are the movements of the Hang Power Snatch and the Hang Power Clean the most used. The athlete acquires techniques and motor skills while refining and perfecting them, making with the technique the characteristic of most relevance to athletes in that sport. There are three possible trajectories of the right bar that allow the best performance (Vorobyev 1978) as shown in Figure 1 (a, b, c) and as is shown in Hang Power Snatch (Figure 1d).

Therefore, research studied the kinematics bar trajectory during the performance of the weightlifting in competitive athletes (Garhammer 1984, Enoka 1988, Haug, Drinkwater et al. 2015, Kipp and Harris 2015), and others have studied the trajectory of the bar in different positions of the body and its relationship with the kinetic performance (Stone, O’Bryant et al. 1998, Schilling, Stone et al. 2002, Winchester, Porter et al. 2009), all of them confirming the importance of the technique and that there is a certain graphical representation which represents the trajectory for teaching the movements.

**Figure 1**

Basic types of bar trajectories (a,b,c), adapted from Vorobyev (1978) and bar trajectory representation for Hang Power Snatch
Olympic weightlifting coaches applied Visual Feedback, because this proved to be a facilitator of acquisition of motor skills (Swinnen, Lee et al. 1997, Winchester, Porter et al. 2009) in the use of mirrors as simultaneous feedback (Sewall 1988) or (Rucci and Tomporowski 2010) which used combinations of visual feedback + verbal feedback, being this last combination as the most effective method of acquiring skills for Olympic weightlifting. With the technical advancement of computer graphics appears the avatar, which is a visual representation of a person made by computer and that is currently widely used in interfaces, games and visual environments that allow users to communicate non-verbal orders details successfully, thus increasing perception of action (Steptoe and Steed 2008). Research conducted with anthropomorphic figures whose movement resembled with the human, found that there was participant’s tendency to dynamically adjust motor behavior with the figures represented (Kilner, Paulignan et al. 2003, Kilner, Hamilton et al. 2007). Indeed, there is evidence neurophysiological that certain regions of the brain involved in enforcement actions are activated simply by watching the action, mirror neurons (Gallese 1996, Rizzolatti, Fadiga et al. 1996) and different forms of representation of an performance excites the motor programs used in order to perform the same action (Prinz 1997, Kilner, Paulignan et al. 2003).

This justifies the attempt of the project and implementation of an Avatar representing the movement of Olympic Weightlifting and which is used as extrinsic feedback with knowledge of the performance during the acquisition of motor skills to perform the Hang Power Snatch. The hypothesis guiding this work is that the performance of the weight lift could be improved significantly with an avatar-based VR system with respect to the traditional feedback techniques.

METHODS

A. Participants
One subject, former Olympic Weightlifting champion in international competitions and certified by the Olympic weightlifting Association as high-performance athlete, volunteered to participate in this development. He performed the movement Power Snatch, comprising a load of 70% of a RM (repetition maximum) without technical complications.

B. Experimental Apparatus
Data Acquisition: The motion capture data was recorded by 10 infrared camera Optitrack Motive Body Version 1.7.5 Final 64-bit system at the Integrated Systems Laboratory (LSI) of the Polytechnic School of the University of São Paulo.

37 reflective markers were placed in anatomical landmarks following the Optitrack protocol for Motive Body (Figure 2) to capture the movement by infrared cameras during execution: Head (Top, side, front), Torso (Back, Chest, Left, Right), Waist (front and back for left and right sides), Shoulder (Top, back, for left and right sides), Arm (elbow, triceps for both sides), Hand (wrist out, wrist in, hand out, for both sides), Leg (Thigh, knee, shin, for both sides), Foot (Ankle out, Toe out, Toe in, for both sides)

Material: A weightlifting barbell, with a total load corresponding to 70% of a participant’s 1RM (one repetition maximum).
C. Avatar Creation
The data processing and the rendering of the avatar was performed with a Dell Precision T7610 model computer with Intel® Xeon® processor E5-2620 CPU with 6 core at 2.1 GHz and 15MB cache, with 12Gb of RAM running on Windows operating system 7 Professional 64Bit. For video work, the computer was equipped with a NVIDIA Quadro 2000 mid-range professional graphics solution with memory 4095 MB.

D. Procedures
Data acquisition took two days, 6 video record were made video shoot have been made. Afterwards, the two best acquisitions that have gone through the rendering process in resolution of 1080x720 pixels, taking 16 hours a day each.

RESULTS AND DISCUSSION
The developed version of Avatar will be tested in another study which will be used different feedback methods in order to compare their relevance versus different methods.

Figure 2
Optitrack anatomical landmarks protocol for construction of avatar

Figure 3
Different Avatar frames executing the Hang Power Snatch
Studies investigating the effectiveness of the observation action facilitating learning Hang Power Clean (another derivative movement of the Olympic weightlifting) showed that participants achieved improvements in learning faster technical execution corresponding to 3% (Sakadjian, Panchuk et al. 2014). We believe that the use of the Avatar in teaching Hang Power Snatch will show the best results compared to other types of feedback. As it is indicated by (Rucci and Tomporowski 2010) the type and quality feedback provided during instruction influences the learning of motor skills and this is because when using a visual feedback, the characteristics to be performed are observed without providing details that lead to an error.

For (Nowak and Rauh 2006) the anthropomorphic characteristics of Avatar reduces uncertainty about what is represented due to the ability of perception processes to identify human characteristics in it. This reliability expressed in computer graphics environments attract attention to the detail expressed in it, which will allow focus on the represented action and one of the processes that directly affect the execution performance is the prior concentration of the subject and it would be better both kinematics as athlete performance (Vladimir, Viorel et al. 2014).

CONCLUSIONS
Fitness trainers and/or high sports performances are always looking for the best ways to improve the efficiency and effectiveness of their training programs, athletes and participants complement their training with visual technologies, we believe that the use of Avatar should collaborate in order to be a tool facilitating the acquisition of motor skills or training.

In this work, a feedback tool has been developed and it is being used to validate the performance improvement.

REFERENCES


The purpose of this study was to identify the effect of rule changes in paralympic sport Goalball by using semi-automatic software tools. Goalball is one of the paralympic disciplines designed for visually impaired athletes. Two teams, each consisting of three players try to score goals by rolling the ball into the oppositions’ net. All players wear additional blindfolds to guarantee that players are equally impaired. The ball contains bells allowing players to echolocate its movement. Goalball-specific software was developed for performance analysis (“GoalScout”, “GoalView” and “GoalTrack”). For practical and intuitive scouting purposes the software runs on tablet PCs. Additionally, positional data extracted from video sequences provides precise information. GoalTrack accurately measures the speed of the ball. Bowling patterns were characterized for all teams and players. Significant changes concerning bowls per game in women games were identified (n = 66; p < .05). No significant changes were found in men games (n = 77). Regarding goals per games, neither in men (n = 77) nor in women (n = 66) significant differences were found. Significant scoring sectors were identified (Sector 3 and 7; \( \chi^2 = 7.50, p \leq .005 \)). A correlation between ball speed and success rate is, especially in women games, statistically significant (Men: \( r = .65 \); Women: \( r = .90 \)).

**KEYWORDS:** Goalball, Effect of Rules changes, specific software tools
INTRODUCTION

Goalball, a Paralympic sport since 1976 in Toronto, is designed for visually impaired athletes. The goal is that two opposing teams, each consisting of three players try to score goals by rolling the ball into the oppositions’ net. The court dimensions are the same as a standard volleyball court besides the lines of the court are tactile and are made by placing thick tape over cords. Players wear blindfolds to guarantee equal impairments. The ball contains bells allowing players to echolocate movements. Alternating between offense and defence Goalball shows a very structured game play. Offensively, the ball cannot be thrown until the referee calls “play”. The team has 10 seconds to throw the ball. If the player throws before the call or the ball doesn’t contact landing and neutral area, a penalty is incurred. Defensively, players listen for the ball and try to block it with their bodies. If unsuccessful, the opposing team wins a point. Once the players gain possession, it’s their turn on offense. So far only very few studies in the field of Goalball performance analysis can be found. Notational analysis were done by De Castro Amorim, Da Concejaco Botelho, Sampaio, Saorin & Nunes Corredeira in 2010. The authors identify significant often used throwing positions in offensive plays as well as scoring sectors, divided into left, middle and right. Supporting Finnish national Goalball teams, Lehto, Häyrinen, Blomqvist, Juntunen, Laitinen, Karhunen, und Collet (2012) used statistical software (Data volley) to identify key aspects of Goalball. They figure out, that blocking with hands seems to be an important technique in defence action. The purpose of this study was to light up the effect of rule changes which were introduced in 2014. The main changes were made by deleting the “3-Bowl-Violation” rule and by adjusting the “10-Second- Time” rule. To investigate the effect of rule changes games from 2012 and 2013 were compared to games from 2014 and 2015 which were played by the new rules. Furthermore the progress of Goalball over these years can be modelled with collected data. In order to identify the impact of the rule changes, first the general structure of Goalball must be determined. Therefore this study intends to provide information about general structure of performance as well as the influence of target sector and ball speed analysis.

METHODS AND SOFTWARE DEVELOPMENT

Based on the model “Systematische Spielbeobachtung” by Lames (1994), three software tools, which are specific to Goalball were developed. Grounded on the experience in Beachvolleyball (Link, 2013) GoalScout is a data collection tool, while GoalView analyse data. GoalTrack accurately measures the speed of the ball by using several methods of computer vision to detect the ball. For practical scouting purposes GoalScout runs on tablet PCs. Additionally, positional data extracted form video sequences provides precise information about start and goal sector. More frequently used game characteristics appear situation-related next to the video, which leads to a very intuitive and efficient way of scouting. Based on just 4 to 9 “clicks”, up to 18 game characteristics can be derived for each bowl (see figure 1). GoalView is a specific data analysis tool for Goalball. Using different filter settings, each video sequence of a bowl can be analysed. Furthermore, reports (e.g. statistical, bowl-distribution, Performance Index etc.) can be created in real-time. To determine ball trajectory, GoalTrack uses a multi-stage approach of computer vision. Initially, by using Background Subtraction as well as Colour and Match shaping the position of the ball is detected from the video frame. Following a localization of ground contact points of the ball (minimum of pixel coordinates) plus a projection of ball position to ground level at these times. A result of this, is the regression line of the ball through floor contact points.
Altogether 198 Goalball matches were analysed (Paralympics 2012, European Championships 2013, World Championships 2014, World Games 2015; 100 men games, 98 women games). Software tools were used to analyse each bowl (n = 39351) regarding to all game characteristics shown in table 1. Furthermore GoalTrack was used to measure ball speed (n = 8397).

**Figure 1**
User interface GoalScout. Up to 18 game characteristics can be derived by just 9 “clicks”

**Table 1**
Game characteristics, captured for each bowl

<table>
<thead>
<tr>
<th>Game ID</th>
<th>Bowl ID</th>
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<tr>
<td>Timecode</td>
<td>Team/Player offense</td>
</tr>
<tr>
<td>Team/Player defense</td>
<td>Start position</td>
</tr>
<tr>
<td>Defense position</td>
<td>Ball direction</td>
</tr>
<tr>
<td>Angel of defense</td>
<td>Result of bowl</td>
</tr>
<tr>
<td>Used technique</td>
<td>Flight path of ball</td>
</tr>
<tr>
<td>Kind of defense</td>
<td>Penalty</td>
</tr>
<tr>
<td>Bowl after penalty</td>
<td>Bowl after change court sides</td>
</tr>
<tr>
<td>Bowl after scored goal</td>
<td>Bowl after the change of position of a player</td>
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**RESULTS**
According to Cohen (1960), interrater-reliability between manual and automatically notation of sectors is high (kappaweighted = .807). Interrater-reliability for each game characteristics is very high (k > .90). Bland and Altman (1960) analysis demonstrate a high level of agreement between GoalTrack and Utilius easy inspect (commercial software). For the 95% con-
fidence intervals a lower and higher limit of 1.3 m/s were detected. In general no significant difference between male and female games regards to no. of bowls per game were detected (n = 60, Men = 187.95 ± 20.52; n= 53, Women = 184.60 ± 20.65). The scoring rate for males (M = 9.89, SD = 5.03) is higher than for females (M = 6.78, SD = 4.13) and statistical significant; t (111) = -.802, p < .001. Rotational bowling technique is used by male players (M = 111.49, SD = 43.27) more often than by female players (M=45.54, SD=36.59), t(111) = - 3.846, p < .001. So called “bouncing ball” are used more often by male players (M = 116.00, SD = 40.25) than by female players (M=48.56, SD=24.07) and statistical significant; t (111) = 10.452, p < .001. In men games, there was no statistical significant difference between “rotational” and “regular” bowling concerning scoring a goal, X2 (1, N = 11501) = 1.88, p = .17. Unlike in men games, start of bowling in women games show statistical significant difference for scoring a goal, X2 (1, N = 9095) = 20.22, p < .001. Significant difference using so called “jumpball” to score a goal could be found in men games, X2 (1, N = 11501) = 3.77, p = .020. Highly significant difference concerning “jumpball” and goals show women games, X2 (1, N = 9095) = 29.57, p < .001. Scoring sector analyses show significance positive differences on sector 3 and 7 to score a goal. (See Figure 2; X2 (9, n= 19754) = 7.50, p ≤ .005). A statistical significance low chance to score a goal is on sector 8 and 2.

A correlation between scoring rate and ball speed (n= 8397; Men: r = .659; Women: r = .903) is statistically significant. KS-Test showed, that fast bowling is evenly distributed across matches (n = 895; D = .884, p<.001). The only effect of the new rules is a significant difference is regards to no. of bowls in women games between 2012/2013 (M = 187.75, SD = 20.59) and 2014/2015 (M = 194.93, SD = 9.12), t (110)= 2.734, p < .05.

**DISCUSSION**
In this study, an investigation on the effect of rules changes, which were introduced in 2014 were conducted. In a first step the general structure of performance was analysed. For players and coaches, the fact is surprising that there is no difference in bowls per game between men and women games. Especially games of men seems to act much faster than games of women. But this depends of the speed of the ball. The ball speed...
average in men games is 43.3 km/h instead of 32.02 km/h in women games. As a consequence of this, women frequency regarding no. of bowls per training must be the same as in men training. To play “jumpball” is a performance indicator in women games unlikely in men games. Significant correlation between scoring rate and ball speed, especially in women games recommend a training of basic strength abilities. A significant low scoring probability were found on sectors where defenders can use tactile court information. Scoring sector analysis proved coaches and players opinion that it is easier to score on sectors, where defensive responsibilities of two players overlaps. The amended rules in 2014 only refer to a few areas of the game. The effects have not change the structure of the sport fundamentally. In men games referring to the adjustment of the 10-second-liolation rule the no. of bowls per game is nearly the same. In women games no. of bowls per games increases significant.

CONCLUSION
An adaption of the rules of the game can always cause the structure of a sport fundamentally. Accordingly, it is important to consider the effect of rule changes with scientific methods. In general, the effect of rule changes made by International Blind Sport Association (IBSA) were done very wisely. No major impacts to the structure were detected. Little adjustments by players to the new rules changed players load profile. Depending on team strategies it seems that players specialize on offense and defence, referring to the remove of the 3-Bowl-Violation-Rule. It is difficult to consider these observed behaviours. First, those observations must always be examined for individual players and teams. Secondly, in national teams, not always the same players are nominated. This may involve amending the tactics referring to strengthen and weaken of the own players.

REFERENCES


ACKNOWLEDGEMENT
This project was funded by German Institute of Sport (IIA1-070405/12-13 and IIA1-070406/14) to develop state of the art software for performance analysis in Goalball.
Purpose: The author used mathematical models to analyze world records in track and swim events in order to find out the social factors, economic factors, historical factors and scientific factors that have affected the progression of world records. Method: 1825 pieces of swimming and track events world records were analyzed by ARIMA model and independent sample t test. ARIMA model demonstrated the following characteristics: new WR rate rose in 1912-1928 years initially, then the rate began to decline; the second rise period started in 1943, the rate began a downward trend after 1976 except that in 2008 and 2009, the new WR rate was much higher than average number compared to the year between 1976-2014. The results also showed 4 periods of troughs in new WR rate: the first period was 1913-1918, the second was 1939-1946, the third was 1990-1997, and the last one was 2010-2014. In following 30 years, the probability of new world records will be maintained at a stable and very low level of rate (0.16), provided the human gene and morphology, technology and other conditions are not changed. The other finding of this paper was that annual mean of new WR of events started after 1950 was almost 2 times than that of events started before 1950. Conclusions: Science and technology were the driving factors for the improvement of new WR rate; war seriously hindered the development of sports; doping was contributed to the peak period of new WR rate; the combination of sports and business changed sports training and competition theories, consequently, athlete’s body becomes more fragile, and sports life shortened. The reasons for swim events showing higher annual mean of new WR than track events are the differences in sports techniques, movement environment and the sports mechanics.

**KEYWORDS:** track; swim; analysis; history; future

**IS THE HUMAN PHYSIOLOGICAL BOUNDARY COMING? AN ANALYSIS OF WORLD RECORDS’ PROGRESSION AND FUTURE**
INTRODUCTION
Only one world record (men’s decathlon) was broken during IAAF World Championships in Beijing 2015, and none world record was broken during IAAF World Championships in Moscow 2013. People will ask whether the human physiological boundary is coming, how fast human kind can run, and how many world records can be broken in the future. Honestly speaking, creating new world records are influenced by the social system, economic development level, history, science and technology level as well as the physical quality of athletes, genetic, psychological performance, human evolution, training conditions, equipment, and so on. Although creating new world records appeared to be accidental phenomenon, in fact there was its inherent law. The author used mathematical models to analyze world records in track and swim events in order to found out the social factors, economic factors, historical factors and scientific factors that have affected the progression of world records.

METHODS
Statistical analysis. 1825 pieces of swimming and track events world records were analysed by ARIMA model and independent sample t test. Autoregressive integrated moving average (ARIMA) model is a generalization of an autoregressive moving average (ARMA) model. These models are fitted to time series data either to better understand the data or to predict future points in the series (forecasting). They are applied in some cases where data show evidence of non-stationary, where an initial differencing step (corresponding to the “integrated” part of the model) can be applied to reduce the non-stationary.

For the world records of sports, the world record is gradually being refreshed over time. The time and events are generated randomly; however the trends are towards higher levels of direction. For the forecast of world records, make full use of time-series data resources and historical changes, ARIMA model is more appropriate to predict the future development in a certain extent, so this paper mainly uses ARIMA model for analysis.

RESULTS
Between 1912 and 2014, some of the events across the entire period, but some of the events are developed during this period. Therefore, it is not accurate to only calculate the new WR of each year, but to find a uniform amount to describe the ratio of new WR. We define factor $\lambda_t$ as the annual ratio at the year $t$ of the new WR number over the total number of events. $\lambda_t = \frac{\sum (\text{new WR})_t}{\sum (\text{Event})_t}$. 1825 pieces of swimming and track events world records were analyzed by ARIMA model and independent sample T test. ARIMA model statistical results showed that the progression of the world record in track and swimming events demonstrated the following characteristics: $\lambda_t$ (ratio) rose in 1912-1928 years initially, then the ratio began to decline; the second rise period started in 1943, the rate began a downward trend after 1976 except that in 2008 and 2009, the $\lambda_t$ was much higher than average number compared to the year between 1976-2014. The results also showed 4 periods of troughs in $\lambda_t$: the first period was 1913-1918, the second one was 1939-1946, the third one was 1990-1997, and the last one was 2010-2014. In following 30 years, the ratio is difficult to have explosive growth. The probability of ratio will be maintained at a stable and very low level (0.16), provided the human gene and morphology, technology and other conditions are not changed. The other finding of this research was that the $\lambda_t$ of new of events that started after 1950 was almost 2 times than that of events that started before 1950.
Table 1
Data Summary

<table>
<thead>
<tr>
<th>Event</th>
<th>Event Number</th>
<th>Men's Event</th>
<th>Women's Event</th>
<th>WR. Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track</td>
<td>36</td>
<td>18</td>
<td>18</td>
<td>621</td>
</tr>
<tr>
<td>Swim</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>1204</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>38</td>
<td>38</td>
<td>1825</td>
</tr>
</tbody>
</table>

Note: Data Range (Year 1912-2014)

Table 2
Annual Mean of New WR of Group Statistics

<table>
<thead>
<tr>
<th>Annual New WR Mean</th>
<th>Starting Year</th>
<th>Event No.</th>
<th>Mean</th>
<th>One Sample K-S Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;= 1950.</td>
<td>33</td>
<td>.6092</td>
<td>0.285</td>
</tr>
<tr>
<td></td>
<td>&lt; 1950.</td>
<td>43</td>
<td>.3614</td>
<td>Asympt. Sig. (2 tail)</td>
</tr>
</tbody>
</table>

Table 3
Annual Mean of New WR of Independent Sample Test

<table>
<thead>
<tr>
<th>Annual New WR Mean</th>
<th>Levene's Test for Equality of Variances</th>
<th>T-Test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>1.433</td>
<td>.235</td>
</tr>
</tbody>
</table>

Figure 1
New WR. Ratio ARIMA Difference Data Processing (Observed, Fit, Forecasts)
DISCUSSION

1. Social and historical impacts on new WR ratio
In a past century, the most significant historical events that have huge impact on sports development were World War I&II. During World War I (1913-1918), the mean of $\lambda$ (ratio) was 0.05, much worse mean of $\lambda$ (ratio) was appeared during World War II (1939-1946), it was only 0.01.

During 1918-1928, when the colonial expansion of west counties led spread of sports events to other countries, we saw the first climbing of new WR ratio. The process of industrialization and mass production liberated the labor force, and many middle and lower classes in Europe and the United States began to participate in sports activities. Sports were no longer an exclusive right of higher class people, and they had the economic base in the leisure time to engage in sports activities. Consequently, these social changes made sports population increased significantly, which setting up a solid foundation for improving the physical performance.

2. Doping impacts on new WR ratio
Doping made great contribution of new WR ratio reaching the peak during 1950-1980 in history, while it caused negative effects on sports ethics, athletes’ body and fair play. One secret archive of doping control center was exposed, which in past two decades, most WR holders had the tradition of long term using the banned substance, and they had pass in doping test successfully guided by physiologists.

Scientific and regulated doping test was adopted since 1961 in order to eliminate the negative effects on sports circle. We saw the new WR ratio dropped after 1972 because of doping control. Strict doping test caused athletes not daring to use banned substances, undoubtedly, between 1940s and 1970s—even longer, when the doping test technology was not very advanced, drug use was indeed exist in sports circle, and it had become a stain in sports history.

3. Sports commercialization impacts on new WR ratio
The combinations of media and sports have opened the door of sports fortune. Hosting mega events have made considerable fortune for international sports organizations. Businesses corporations have invested billions to advertise at mega events. International sports organizations have developed as many as possible sports competitions in order to make financial revenue. Athletes have participated in too many competitions to consume their body in order to win the bonus, before long their sports life will be doomed. If the most critical factor—athletes performance does not have a long and stable state, then the new WR ratio growth will become very difficult. Diagram 5 showed that new WR ratio in 1984 was 0.5, and then it descended gradually.

4. Science and technology impacts on new WR ratio
It was that sports science and technology made a great contribution to new WR ratio reached the peak between 1950 and 1980, when 40% of total new WRs were created during this period. Science and technology shortened the life” of WRs, which new WR ratio in this period was more than 0.4, especially in 2008, 16 WRs were created in swimming pool, and 15 of them were due to the athletes wearing fast swimsuit.

5. When the human beings can stop creating WR?
ARIMA model showed that new WR ratio will be maintained at 0.16 in next 50 years. Creating new WR could be the impossible mission for athletes, but it will not ever end. French Scientist Berthelot – G, el founded in their research that in 2007, WR have reached 99% of their asymptotic value. Present condition prevailing for next 20 years, half of WR will not be improved by more than 0.05%. We also found a very interesting result that the Annual Mean of New WR (0.6092) of events that started after 1950 was almost 2 times than that (0.3614) of events that started before 1950, and 60% swimming events were started after 1950, only 25% track events were started after 1950, so we can say that the “New” events have more possibility to break WR than “old” events. 3 main reasons may explain the results: first, technical factors. Swim skills are more complicated than running skills. Second, exercise environment. Human are land creature and be more familiar with land compared to water. Third, sports mechanical factors. Athletes will get more resistance in water than in land.
CONCLUSIONS

Literature analysis showed that science and technology were the driving factors for the improvement of λ (ratio); war seriously hindered the development of λ (ratio); doping was contributed to the peak period of λ (ratio); the combination of sports and business changed sports training and competition theories. Consequently, athlete’s body becomes more fragile, and sports life of athletes shortened. The reasons for swim events showing higher in Annual New WR Mean than track events are the differences in sports techniques, movement environment and the sports mechanics.

REFERENCES

The present research aimed to study the visual memory and visual pursuit of three different sports such as cricket, badminton and basketball among male and female athletes with the help of the Vienna test system. Sixty subjects, 30 male and 30 female (N= 10 in each category) were randomly selected for the study. MANOVA was applied at 0.05 level of significance. There was no significant difference between males and females when considered jointly on the variables visual pursuit and visual memory (Wilks’s $\lambda = .970, F(2,53)= .809, p= .451$, partial $\lambda^2 = .030$). There was no significant difference between various sports (i.e., cricket, badminton and basketball) when considered jointly on the variables visual pursuit and visual memory (Wilks’s $\lambda = .919, F(4,106)= 1.147, p= .338$, partial $\lambda^2 = .041$). The interaction effect was also found to be non-significant between gender and sports (Wilks’s $\lambda = .969, F(4,106)= 4.23, p= .041$, partial $\lambda^2 = .041$). The result may be attributed to the level of participation and a novel attempt by the subjects as the sports involved have their own unique nature. The athletes reported their experience as unique as they were involved in this kind of test for the first time and wanted it to be a mode for training.

**KEYWORDS:** Visual Memory, Visual Pursuit, VTS
INTRODUCTION
A lot of interest has developed around the effect of vision on sport performance ever since researchers from Columbia University reported that the visual skills of Babe Ruth were 12% faster than other athletes. Psychomotor learning is one of the three domains, or broad categories, of educational behaviors. It is based on manual or physical skills, and includes fine and gross motor dexterity, coordination, and movement. The focus is on physical and kinesthetic forms of learning. This domain can also involve communication skills, such as public speaking or computer charting abilities (Vicky, 2009). Visual memory assesses visual memory performance by measuring how respondents receive and replay visual information. Whereas visual pursuit measures visual orientation ability and skill in gaining an overview that are used to assess the more complex dimensions of perception. Poliszczuk (2009 & 2013) on basketball & badminton, Gierczuk (2012) on elite wrestlers and taekwon-do competitors conducted studies to assess various coordinative motor skills with VTS and linked it to various aspects.

The present research aimed to study the visual memory and visual pursuit of three different sports such as cricket, badminton and basketball among male and female with the help of the Vienna test system measuring visual pursuit and visual memory. It is hypothesized that there would be significant difference between male and female athletes in their visual memory and visual pursuit and there would be significant difference among various sport groups.

METHODS
To serve the purpose of the investigation, sixty subjects, thirty male and thirty female (N=10 in each category) from sports of cricket, badminton and basketball were randomly selected for the study. Subjects were selected from the students of Lakshmibai National University of Physical Education, Gwalior, India.

The instruments and variables selected for this study were as follows: Vienna test system (VTS)

a. Visual Memory Test (VISGED): The test form used is S11. The test items based on an explicitly designed construct assess the capacity of the visual memory which also plays an important role in the orientation process: the development of a so-called, knowledge of how to remember characteristic marks. This test assesses visual memory performance by measuring how respondents receive and replay visual information.

b. Visual Pursuit Test (LVT): test form used is S3. With the LVT the aspect of visual orientation performance is assessed, which consists in pursuing simple visual structures in a relatively complex environment, in a target-oriented way, under time pressure and ignoring distractions. It is also suitable for the diagnostics of the selective attention in the visual area. This test helps in the assessment of visual orientation ability and skill in gaining an overview.

The subjects both male and female of various sports of cricket, badminton and basketball were explained regarding the test and its protocol and after clarifying their doubts were tested on the psychomotor variables of visual memory and visual pursuit. Finally all the data collected was analyzed to draw a conclusion with regard to the hypothesis.

The statistical technique applied in order to examine the hypotheses of the study were, descriptive statistics such as mean and standard deviation and comparative statistics of multivariate analysis of variance (MANOVA). SPSS 20 was also used.

RESULTS
The results of various sports groups of male and female athletes in the comparison of the psychomotor variables i.e., visual memory test and visual pursuit test are presented in tables and interpretations are given accordingly. The mean scores of visual memory and visual pursuit is presented in figure 1.
Figure 1
Mean Scores of Visual Memory and Visual Pursuit between Male and Female Athletes of various Sport Groups

Further the multivariate analysis of the data was computed that has been presented in table 1.

Table 1
Multivariate Analysis between Male and Female Athletes of Various Sport Groups

<table>
<thead>
<tr>
<th>Effect</th>
<th>Value</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pillai’s Trace</td>
<td>.081</td>
<td>1.146</td>
<td>4.00</td>
<td>108.00</td>
<td>.355</td>
<td>.040</td>
</tr>
<tr>
<td>Wilks’ Lambda</td>
<td>.919</td>
<td>1.147</td>
<td>4.00</td>
<td>106.00</td>
<td>.338</td>
<td>.041</td>
</tr>
<tr>
<td>Hotelling’s</td>
<td>.085</td>
<td>1.107</td>
<td>4.00</td>
<td>104.00</td>
<td>.357</td>
<td>.041</td>
</tr>
<tr>
<td>Roy’s Largest</td>
<td>.081</td>
<td>2.198</td>
<td>2.00</td>
<td>54.00</td>
<td>.121</td>
<td>.075</td>
</tr>
</tbody>
</table>

| Sport | Trace | Pillai’s Trace | .030 | .809 | 2.00 | 53.00 | .451 | .030 |
|       |       | Wilks’ Lambda  | .970 | .809 | 2.00 | 53.00 | .451 | .030 |
Table 1 represents the multivariate analysis among sports groups (i.e., badminton, cricket and basketball) in the factors of visual memory and visual pursuit. The value of Wilks’ lambda of the sports group in the tests of visual memory and visual pursuit (0.919) was found to be insignificant at 0.05 level of significance (p=0.338). Hence further one way analysis of variance was not conducted between various sports groups in the factors of visual memory and visual pursuit.

The value of Wilks’ lambda of the gender (i.e., between male and female athletes in the tests of visual memory and visual pursuit (0.970) was found to be insignificant at 0.05 level of significance (p=0.451). Hence further one way analysis of variance was not undertaken between male and female athletes in the factors of visual memory and visual pursuit.

The value of Wilks’ lambda of the sport and gender (0.969) was found to be insignificant at 0.05 level of significance (p=0.792). Hence further one way analysis of variance was not done between male and female athletes in the factors of visual memory and visual pursuit.

DISCUSSION
Abernethy & Russell (1987) conducted an experimental study on the visual search characteristics of 15 expert and 16 novice badminton players were recorded as they performed a film test designed to assess their anticipatory cue usage. Experts were found, from the film task, to be able to pick up earlier advance information than novices and this appeared to be related to their reliance upon the arm, in addition to the racquet, as a source of anticipatory information. Phomsoupha & Laffaye (2014) research on badminton players indicated that they are visually fit, picking up accurate visual information in a short time. Quintana, et al. (2007) conducted a study on the perceptual visual skills in young highly skilled basketball players. On the test battery, visual abilities were monitored in 473 players of the Spanish Basketball Federation over a 5-yr. period. The players showed outstanding scores on distance visual acuity and stereoscopic vision, and good visual reaction times and horizontal visual fields. Though there have been various findings but the present finding of not being significant according to sport and gender may be owing to the small sample size and all the subjects though they belong to various sports are of collegiate level.

Table 1

<table>
<thead>
<tr>
<th>Effect</th>
<th>Value</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Hotelling's</td>
<td>0.030</td>
<td>0.809</td>
<td>2.00</td>
<td>53.00</td>
<td>0.451</td>
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<td>Roy’s Largest</td>
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<td>2.00</td>
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<tr>
<td></td>
<td>Pillai’s Trace</td>
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<td>0.430</td>
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<td></td>
<td>Wilks’ Lambda</td>
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<td>0.423</td>
<td>4.00</td>
<td>106.00</td>
<td>0.792</td>
</tr>
<tr>
<td>Sport Gender</td>
<td>* Hotelling’s</td>
<td>0.031</td>
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<td>4.00</td>
<td>104.00</td>
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<tr>
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<td>Roy’s Largest</td>
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</tr>
</tbody>
</table>
CONCLUSION

The research in this area is just a humble beginning, but further research should be conducted in this area as it is a thrust area in sports, which will only aid in furthering the literature in sports. The research showed that the multivariate analysis among various sports groups (basketball, cricket and badminton) and between gender (male and female) of various sports groups were spastically not significant.

All sports such as the sports chosen in this study demand a great deal of visual memory and orientation, it has been proved in a numerous studies that the sportspersons require a great deal of visual memory and perception due to the necessity of the various sports which has developed into a competitive business, which have been aptly stated in the various studies such as Abernethy & Russell (1987) on badminton players, Quintana et al, on basketball players and Mcleod (1987) on cricket players.

REFERENCES


This research work describes development software applied to strength training. This system allows the training plan (mesocycle, microcycle and sessions), structuring the distribution of training loads based in exercises derived of weightlifting, recognizing the athletes needs and the characteristics of the game in terms of physical requirements. The coach can display training load curves, control perform and check the progress of the process according to the objectives.

**KEYWORDS:** strength training, training loads, weightlifting, physical requirements.
INTRODUCTION
The planning has become a necessity inherent in the search of sporting objective. Besides, training planning has been a completely manual process, which requires for the coach a specific knowledge among experience, becoming like that a daunting task. Besides this, the coach should compare the plan with the achievements gained in the process of training and go changing and adapting the plans to the demands of the game.

The excessive information collected is accumulated in papers; as a result, it becomes more difficult to process. All this will be minimized by systematizing the information in the software. Generally, in sports, there are few tools designed for planning and control training, especially for strength training. Dick, (1993:255) in his book “Principles of sports training” describes the strength as a basic feature which determines the effectiveness of sport performance. In particular this system provides the coaches an easier way to plane the strength training sessions, organize and display the curves of training loads and make changes according to the variables involved and to the objectives to be achieved.

METHODS
This software is based in the monograph “Strength Training for basket players” presented by Professor José Echeverri Ramos (2004), in which the general objective is to introduce a method of training based on weightlifting exercises.

The monograph presents a specific methodical structure which takes as the main consideration “the knowledge” about the sequence of body movements and joints used in competitions. In these words, the structure takes into account the characteristics of the game and the intervention of the athlete, and according to that, it will be possible to identify the training load.

Otherwise the weight-lifting exercises proposed are: squat, jerk, pull and snatch and the use of the average relative intensity (ARI).

The information that is initially saved is about: 1) the weight that the competitor can lift-up in the proposed exercises; 2) the ARI of each exercise; and 3) the competitive level of each athlete, known as: advanced, intermediate and beginners (A, B, C respectively) (Figure 1)

![Figure 1](image URL)

Registration interface
The next interface is to type the percentages of each exercise worked and the number of the repetitions done during the mesocycle and the microcycles, as well. Then, the system gives back displaying the number of repetitions to be done in each microcycle according to the percentages typed (Figure 2).

![General configuration interface](image)

**Figure 2**
General configuration interface

Another interface shows the distribution of the load for each exercise. (Figure 3).

Finally, the number of week-days is selected to able the text field to type the percentages. Then, the repetitions are distributed weekly and the system automatically displays the number of days to work and the number of repetitions to do those days.
RESULTS
The system automatically shows that the strength training plan must be followed among the athlete, allowing the coach to streamline plan processes, and at the sometime, avoiding mistakes on the data, and displaying like that the load undulation on the mesocycle and macrocycle plans, and thus, be able to make corrections before the entire plan.

DISCUSSION
The system allows the trainers to carry out a program of training of the strength development, taking as a basis, the athletes’ needs and the general configurations of each sport. It is important to highlight that the system is designed for a sport like basketball, but is scalable to any sport in which required the explosive strength training to achieve the objectives.

Software development has several steps in the process, program was first developed in excel as a tool for loads systematization, then, program was developed in Visual Studio, having some complications for the compilation. In this moment the software was developed in Java and it has been proved with Antioquia basketball women’s team, they won in National games and National ultimate master women´s team.

CONCLUSION
In this planning is indispensable to bring a control and monitoring the work that is done to ensure that objectives are being met raised; this tool allows to do all this process in a systematic manner and intuitive, to save time and effort in the individual check training-plan, covering the needs found, whether amateur or professional.

In addition it permits to export all the information including yield results. On the other hand, the coach and even athlete have the training plan to hand at the time of training session, and it could also display the training-load and curve graphs to view what is possible to modify.

REFERENCES
The purpose of the present study was to assess the effect of intensity manipulation of Olympic lift training on the sprinting ability of 100 meters sprinters. The subjects were 30 male elite sprinters of 18 to 25 years of age group from Lakshmibai National Institute of Physical Education, NERC. They were assigned into 2 groups: A (Intensity manipulation of Olympic lift training; n=15) and B (control; n=15). The training was given for a period of 6 weeks. The experimental groups were trained thrice a week, while the control group continued with their daily routine work. The performances of sprinting ability of the subjects were taken by the Smart Block. The different sprinting ability- Run time, Raw time, Reaction time, Peak force (R), Peak force (L) Push time and Timed runs were measured with the use of a smart block The between-group differences were assessed using the student’s t-test for dependent data. The level of p 0.05 was considered significant. Significant between-group differences were found for Run time (t=3.00*), Raw time (t=3.03*), Reaction time (t=5.84*), Peak force (R) (t=4.40*), Peak force (L) (t=3.82*), Push time (t=2.48*), and Timed runs (t=2.93*), since the computed value of t for all the dimensions were greater than the tabulated t.05 (14) =2.145. The result was found that the sprinters significant difference in their sprinting ability components

**KEYWORDS:** Intensity Manipulation, Olympic Lift Training, Sprinting Ability, Sprinters, Smart Block, University Athletes
INTRODUCTION
Today the sports persons are trained scientifically with the latest training methods and sophisticated instruments for higher performance improvement in different sphere of sports. Training is not a recent discovery. In ancient times, people systematically trained for military and Olympic endeavors. Today athletes prepare themselves for a goal through training (Tudor, 1999). In the recent years greater stress has been laid on the quality rather than the quantity of training. The sports scientists and experts of sports want their sportsman to extract maximum achievement from their training procedure without causing too much strain on them (Asha, 1980). Over the years this form of training has been employed extensively to improve many power oriented movements in a variety of sports. There are many variations on the theme of power training. Some of these training principles include plyometrics, assisted and resisted training and speed and acceleration drills. A popular method used to increase athletic power is Olympic lifting (ie power cleans, push presses, snatches, jump jerks and their variations) conducted in the weight room. This has traditionally been seen as an effective way of producing general explosive ability. However, considering motor skill and neurological aspects of movement, the logic of employing Olympic Lifts in power training becomes unclear. Therefore, the interpretation and application of Olympic lifting to the development of power will be considered (Takano, 1992).

Smart block will increase the athlete personal best. Smart block help to customized start optimized each athlete the unique ability. Smart block is a brilliant invention to uses panel technology smart block uses the audible “On your marks” at audible set and audible gun start smart block store performance status for each run. Smart block help your athlete achieve faster reaction time.

METHODS
Subjects
A total thirty (15 experimental and 15 control) athletes of Sports Authority of India, Guwahati has been selected for this study. Their mean height, weight, and age were 1.87±0.04 m; 76.5± 5.2 kg, 23.5± 0.4 years. The purposive sampling technique was used to attain the objectives of the study. All the subjects, after having been informed about the objective and protocol of the study, gave their consent and volunteered to participate in this study. They were further divided into two groups N = 15 each (i.e., N1=15; Experimental and N2=15; and Control). The study was further delimited to selected sprinting ability components i.e., (Run time, Raw time, Reaction time, Peak force (R), Peak force (L) Push time and Timed runs).

The Instant Feedback App provides the ease-of-use and actionable, measureable data that coaches need to make the effective adjustments necessary to improve the performance of their athletes. The screenshot of the Instant Feedback app, with accompanying individual screenshots explaining the type of data that is captured. The ones measured were as follows:

- Run time: Run time gives time runner an indication of whether their efforts/changes resulted in a faster time. The score is recorded to the nearest 1/10th of a second.
- Raw time: Raw Time shows how fast the athlete ran once they started moving. This shows the real effort of the run and disregards reaction time.
- Reaction Time: Reaction Time the time from the gun sounds to when the athlete pushes on the pedals.
- Peak force (R): Peak Force is the highest force generated from pedals during the drive off the blocks. This is as (R) for right pedal. The score is recorded to the pounds (lbs). Peak Force (L): Peak Force is the highest force generated from pedals during the drive off the blocks. This is as (L) for left pedal. The score is recorded to the pounds (lbs).
- Push Time: Push time shows how long an athlete pushed on the pedals.
- Timed Runs: Timed Runs Eye-Beams can be set at a particular distance to time a run.

Six Week of Olympic Lift Training Programme:
Subjects were trained thrice a week i.e. on Monday, Wednesday and Friday. The subjects performed Power Clean, Snatch, Push Press, Push jerk and Split jerk. 10-15 repetitions in each of the 3 sets, with 50% weight
of 1 repetition maximum and with 3 min recovery period in between each set. Finally for last three weeks the exercises were performed with 60% weight of 1 R.M., 10-12 repetitions in each of the 3 sets with 2 min recovery period in between sets.

Figure 1
A - Power Clean; B - Romanian Dead Lift; C - Hang; D - Split Jerk; E - Clean Push Press; F - Hang Snatch.

Data Analysis
The Instant Feedback App provides the ease-of-use and actionable, measureable data that coaches need to make the effective adjustments necessary to improve the performance of their athletes. Student’s t-test was used to assess the between group differences. The level of p≤0.05 was considered significant.

RESULTS
The study was conducted to assess the effects of intensity manipulation of Olympic lift training on Sprinting ability of 100 meters Sprinters. The statistical analysis of data collected on thirty (N=30) subjects. The finding have shown the significant value of F-ratio’s for selected variables in the experimental training group as compared with the control group. No significant changes over that 4-week period were noted in the control group. The graphical representation of responses has been exhibited in Fig 2.

The hypothesis was rejected because of significant differences were obtained in the sprinting ability of sprinters. The results pertaining to significant difference, if any, between experimental and control groups were assessed by “t” test and are presented in following tables.
Table 1
Sprinting ability of Experimental Group Paired Samples t-Test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Olympic Lift</th>
<th></th>
<th></th>
<th></th>
<th>Control Group</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>t-value</td>
<td>Pre</td>
<td>Post</td>
<td>t-value</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Run time</td>
<td>2.52</td>
<td>2.51</td>
<td>3.00*</td>
<td>2.53</td>
<td>2.53</td>
<td>0.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw time</td>
<td>0.13</td>
<td>0.12</td>
<td>3.03*</td>
<td>0.13</td>
<td>0.13</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction time</td>
<td>2.40</td>
<td>2.29</td>
<td>5.84*</td>
<td>2.40</td>
<td>2.38</td>
<td>1.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak force (R)</td>
<td>27.46</td>
<td>23.8</td>
<td>4.40*</td>
<td>27.13</td>
<td>28.53</td>
<td>1.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak force (L)</td>
<td>52.26</td>
<td>59.2</td>
<td>3.82*</td>
<td>52.4</td>
<td>56.26</td>
<td>1.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push time</td>
<td>0.15</td>
<td>0.17</td>
<td>2.48*</td>
<td>0.148</td>
<td>0.159</td>
<td>1.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timed runs</td>
<td>0.16</td>
<td>0.19</td>
<td>2.93*</td>
<td>0.167</td>
<td>0.186</td>
<td>1.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2
Performance parameter of sprinting ability of sprinters before and after training

Significant between-group differences were found for Run time (t=3.00*), Raw time (t=3.03*), Reaction time (t=5.84*), Peak force (R) (t=4.40*), Peak force (L) (t=3.82*), Push time (t=2.48*), and Timed runs (t=2.93*), since the computed value of t for all the dimensions were greater than the tabulated t0.05 (14) =2.145. Thus it is concluded that the sprinting ability components of sprinters found to be statistically significant.

DISCUSSION
Weight training depends on the individual, though considers it an important part of training programme. If everything else is equal among sprinters, the strongest sprinter will be the winner. Be consistent in the way you set the blocks. Put your strong leg in front. Your starting position should be comfortable, balance. For better performance in sprinting emphasize should be as relaxed as possible while running. Keep mouth open slightly. Relax jaw and entire face, even eyes. Don’t grit teeth. Proper running form helps to run efficiently and positions to move as quickly and powerfully as one can. The angle of your body to the ground should be slightly forward, so that pushing off the ground while running. The body should be straight but leaning slightly forward. Finally proper Run time, Raw time, Reaction time, Peak force (R), Peak force (L), Push time and Timed runs is important to running best.

All the energy should be used to go forward. About two-third of the race is acceleration. Then enter the stage where sprinter try to maintain speed. Many
races won and lost in the last 10 to 15 meters where the sprinter slowing down, trained sprinters just slowing down less than everyone else. How to become a better Sprinter, Carl Lewis and Tom Tellez. The factors that sprinters should look for setting up the starting block, the optimal ‘set’ position for an athlete, and what an athlete should do during the acceleration phase of the sprint to maximize performance. The present study showed that the between-group differences were found for Run time (t=3.00*), Raw time (t=3.03*), Reaction time (t=5.84*), Peak force (R) (t=4.40*), Peak force (L) (t=3.82*), Push time (t=2.48*), and Timed runs (t=2.93*), since the computed value of t for all the dimensions were greater than the tabulated t.05 (14) = 2.145.

CONCLUSION
In conclusion, the present study suggests that 6-week intensity manipulation of Olympic lift training had significant effect on sprinting ability of sprinters. These data provide more scientific evidence to support the beneficial effect of intensity manipulation of Olympic lift training on sprinting ability and thus, such training may be recommended to improve physical and physiological based performance.

ACKNOWLEDGEMENTS
Authors would like to thank weight training in charge for providing assistance in collecting the relevant information for undertaking quality research.

REFERENCES
TEAM
SPORTS
In football clubs there are different, traditionally isolated sources of information. This results in fundamental need for a central club information system (CIS). The conceptual development of such a system is the purpose of this research. The focus of this study is to combine data of the performance diagnostics and medical data for a model of healthy reference patterns. Therefore special standardised tests were developed and performed with a team of U17 (n=17) players from a German Bundesliga club. The aim is to make this data accessible for the employees of a football club by specific retrieval software.

**KEYWORDS:** Soccer, information systems, healthy reference pattern, performance analysis, software development.
INTRODUCTION

In top-level football clubs information is typically generated by many different sub-systems and sub-organisations. There are different sources of information (such as club-management, public relations, team-management, medical data, athletics... etc.) and every field has its own systems to generate and store this information (Lames, 1997). Players and employees are shifting between clubs. Standardised long-term information about each player is difficult to get, especially in performance diagnostics and medical. This paper presents the idea of developing a management information system (MIS) for professional football clubs that focuses on the combination of data from performance analysis and medical. The main issue is to develop a model for healthy reference patterns that makes it possible to analyse the health status of each player at one specific point to determine the medical status. For healthy reference patterns different tests have been chosen to describe the health status of players as accurate as possible. This healthy reference patterns then could be used for injury prevention and additionally for rehabilitation after injuries have happened. The MIS should provide a tool that can help analysing the data and eases the access to crucial information for the relevant employees in their daily work.

METHODS

The chief objective of the development is that the software model should meet the needs of the football club employees. Therefore it’s important to detect how they work, which data is relevant for them and in which form data is needed. Consequently, interviews with the employees of the club had been done, leading to four tests that have been finalized: 3D motion capturing for gait analysis, maximum strength, drop jump and a 3D body scanner. Additional tests were also included (sprinting, dynamical jump and shooting) but currently they’re not part of the healthy reference pattern.

The 17 players were divided into two groups. Each group had passed through the tests. At IsoMed they had done knee extension and knee flexion of each leg three times. The angle of the knee was 90° and the test was static. For the gait analysis a treadmill and a Vicon 3D motion capturing system with 10 cameras and “Plug-in Gait” model for the lower body (16 markers) have been used. The test persons had to act in two speed levels (8 km/h = walking / 12 km/h = running). After two minutes of warm up, they had performed a flying start. For every speed level, one minute was measured.

For Drop Jumps Opto Jump with optical detection was used to measure the ground contact time. The test persons had to start from a 30 cm step and had to jump single leg over a 24 cm hurdle as fast as they could. They had to do three tries for each leg. For the bodyscan, a Vitus 3D Body Scanner (300 dots per cm²) had been used (see figure 1).

Figure 1

Model of the body after body scan (300 d/cm²).

Every measuring point could be used to measure the distance and angle. With this model, there are many options to get metrics of each players’ body.
RESULTS
Currently we work out, which combination of data is relevant. The 3D motion capturing data will be used to analyse the joints and rotation of knee and ankle. Gait graphs will be created to compare them with normal standard values for prevention and also to compare further analysis with the status quo (see figure 2).

DISCUSSION
The current situation makes it necessary to get more information about health status of players. This study should develop a model that could help to solve this problem. Further research will show if healthy reference patterns could be useful and how they could be used in sport practice. After that, the influence of such data in prevention and rehabilitation has to be evaluated.

CONCLUSION
This study tries to develop healthy reference pattern or patterns? As next module for the CIS. Therefore it is necessary to get first data sets, bring this data together in an appropriate software and make it accessible for medical professionals. That could deliver the base for developing such systems further. But healthy reference pattern siehe oben as part of CIS could help medical professionals to get long-term information of their
players. They also get an impression of the players condition before the injury happened and could use this information for further treatment and match the previous health status with the status quo. The CIS could be a tool to work with this data and help to develop it further.

REFERENCES


Appropriate execution of the strategy in a game requires an efficient training process, which depends on the criteria applied to select the contents from the team strategy. The purpose of this study is to present an automated solution to the decomposition of a team strategy in the training sessions' contents. First, we applied a formal language to team strategy design. Second, we applied an algorithm to interpret the semantics of each play actions in the strategy designed. Third, the data visualization provided quantitative support to a coach decides training contents. Coaches may beneficiate from this solution by easily assessing the team strategy and previous training sessions to understand his own trends and select the training contents that will be more efficient to improve team performance.

**KEYWORDS:** (6): strategy model, decomposition process, computational system, actions.
INTRODUCTION

In team sports, players’ cooperation is oriented by a strategy, which specifies individual and group actions and, consequently, controls the diversity of a team’s plays. Appropriate execution of the strategy in a game requires an efficient training process, in which the coach defines the strategic contents that the team should practice in each session. Thus, the training process efficiency depends on the criteria applied to select the contents from the team strategy.

The definition of these criteria can be supported by a model of the concept of team strategy (Lamas et al., 2014). In this model, a strategy has been defined as a discrete stochastic system in which a list of actions specified for every player defines the content of a state. Sequences of states define plays and the complete set of plays can be represented through a connected graph. The content of a strategy graph can be alternatively detailed by the sequences of its atomic elements (i.e. players’ actions). The possibility of decomposing the complete structure on its atomic elements provides a precise support for defining contents of training sessions.

In practice, it is difficult to assess the criteria applied by a coach to select contents from the team strategy and design the training sessions. In most of the cases, coaches’ decisions regarding future training contents are qualitative. Quantitative data is not available in most of the time.

The purpose of this study is to present an automated solution to the problem of decomposing the team strategy contents and past training sessions. The defined procedures may be applied to distinct team sports. Nonetheless, herein the application is in basketball.

DESIGN OF TRAINING SESSIONS BASED ON A TEAM STRATEGY

The procedures for defining training session contents based on a team strategy followed some main steps. First, we developed a virtual environment for strategy design, defined according to a previously existent model (Lamas et al., 2014). It guaranteed that a coach’s designed plays could be stored in a database and that the distinct strategies designed by coaches would follow a common structured language, defined by the strategy model that supported the environment structure. Second, once the strategy has been drawn and stored in a database, its specifications should be available to be retrieved and organized in specific reports to support the coach’s decision regarding what will be the training contents. The accuracy of these reports is highly important for training efficiency. Thus, an algorithm has been applied to interpret the semantics of the atomic elements of each play in the strategy designed by the coach and return to him the list with the atomic elements (i.e. team player actions) of each play.

Third, the data visualization organized in these lists added by statistics on usage frequency of each play or atomic elements of the play, in each previous training sessions, provide quantitative support to a coach decide which contents he should select for the next training sessions.

RESULTS

Results encompasses computational solutions both for storing and retrieving information related to the strategy design and for decomposing the strategy contents in possible training contents.

Strategy design

The strategy design structure contemplates:

i) basketball court mapping in x, y coordinates in three major areas, central, left side and right side;

ii) positioning of the players: agility to position the offensive players is guaranteed by sequences of up to five clicks on the court. Defensive players are positioned like offensive players or if the coach prefers, from a special click, automatically positioning each defensive player a meter in front of each offensive player. After an action has been specified for each player, a next state is automatically generated. Sequences of states and respective transitions generate automatically new contents of a graph representation of the strategy being designed;
iii) actions design: offensive and defensive libraries of actions were defined in order to provide the elements that should be used in the action specification of every strategy state, supported by previous studies (Santana et al., 2015; Lamas et al., 2011).

Decomposition process

The team strategy decomposition is an automated process in which the information generated and stored by the system in the strategy design step is retrieved. For this purpose, the coach should inform which plays of the strategy he is considering to practice. The system returns with a list of the plays and its decomposed actions so that the coach can decide between complete plays and part of plays (single or small sequences of actions) to apply in the training sessions. Computational procedures were based on: i) action origin-destination and specific features, such as if the player has or not the ball; ii) matching with library: the library of actions contains the list of actions that can be specified in a state.

In synthesis, the decomposition process discriminates the contents of each state of a team play and presents this information to the coach decide what he will select to practice.

Training sessions

At this step, some of the strategy contents are selected to be practiced. Selection is supported by the automated process of strategy decomposition. A chronological arrangement should be defined, considering the main goal of the training session, its duration and the most convenient sequence of contents. The main elements of training session are: i) Training contents: The list of plays and atomic elements (i.e. actions) of these plays. The coach decides and indicates if he will practice a full play or some of its actions;

ii) Duration: the duration of drills for every strategy content that the coach select to practice is informed. Partial and total duration of the training session is defined and precisely indicated; iii) Coach decision: All data related to the training session design is compiled and presented to the coach. Then, he validates his own design or edit it.

System view

We provide a pictorial view of the system environment in the Panel 1. In the first diagram (top left), we indicate the strategy design module. Then (top central), the graph visualization of the team strategy designed. Each sequence of states, distinguished by colors, is a play. After the semantic interpretation of the contents designed, the decomposition process generates a list of contents related to each play (top right). The coach may consult this list to select the contents he should practice in the training session (bottom right), supported by quantitative data related to emphasis given to each of the contents in previous training sessions (bottom left).
**DISCUSSION**

This work delimited the problem of decomposing strategy contents based on a formal language for designing strategies and presented an automated solution for this problem. It constitutes an innovative approach to organize training sessions in team sports, in which coaches’ decisions regarding what to train can be supported by quantitative data. Coaches are familiarized with the process of planning new contents for the team strategy with plays variations and new options to maximize performance of their team players. In many cases, a coach draws his plays in a software environment and this is helpful to provide clear reading of the contents, with standard notations for identifying players and actions. The coach produces a playbook with all strategy content and communicate it to players and other coaches in the staff. However, the efficiency in retrieving the information and in using it to support decisions on what to train is low because there is no connection with databases. In a theoretical standpoint, it leads to the problem of decomposition.

We approached the decomposition problem by: i) considering a formal language for standardize strategy design; ii) processing the semantics of every action in the strategy; iii) informing the coach these detailed contents based on a previous indication of the general content he intends to practice; iv) providing visualization of his decision result, for validation or edition.

**CONCLUSION**

The decomposition problem is a main issue for improving the efficiency of the training process. In this study, we presented a first approach to it, in which an automated solution is provided. Coaches may benefit from this solution by easily assessing the team strategy in different resolution levels and previous training sessions to understand his own trends in previous sessions. This analysis may contribute to a coach better select the training contents that will be more efficient to improve team performance.

**REFERENCES**


Evaluation Method for Technical Indicators in Ultimate Frisbee

Ultimate is a young sport compared with other team sports like soccer and basketball. The ultimate Frisbee has some peculiarities that make the game very interesting, one of them is that is a no contact game. The aim of this work was to analyze the reliability and validity of technical indicators in the ultimate Frisbee. A survey was applied to 5 experts in Ultimate Frisbee with an experience of 5 years at least in the sport as a player or a coach. This survey aimed to validate technical indicators for game fundamentals in a way to standardize the language between experts and no experts. The results of the survey were used by group of sports experts to elaborate a protocol of variables to be analyzed and validated the methodology for game analysis of some basic technical indicators measured by 3 selected evaluators. The reliability of the observations between evaluators were tested using the Kappa Cohen Test. The test was conducted in pairs for all evaluators and the measurement of agreement was 0.867 (±0.031). The Kappa Cohen values for comparison between evaluators and intra evaluators were very high, showing that the chosen protocol can be applied to evaluate the technical indicators of the Ultimate Frisbee.

**KEYWORDS**: Ultimate Frisbee, game analysis, team sports.
INTRODUCTION
Ultimate Frisbee is a young team sport compared to other sports like soccer and rugby. Originally created in the US in 1903, the young sport had a fast development and spread across the US limits, through the South America and Europe, with the creation of national federations. Today the sport is ruled by the World Flying Disc Federation that was only recognized by the IOC in 2015, making the ultimate Frisbee now eligible for including in the Summer Olympic Games. The main difference between the Ultimate and the others team sports is that the ultimate Frisbee is a non-contact team field sport played with a flying disc. The Ultimate is characterized by being a game of opposition and cooperation where there isn’t a judge to signal any kind of penalties or infractions, while as trial actions are performed by the players themselves, and this fact brings uniqueness to Ultimate. Participants should always cherish the Game Spirit, which is the highest rule of Ultimate. This rule refers to respectful and ethical behavior that should exist among the players because it is up to them the responsibility to point out violations. This is a game with well-defined rules and a number of strategies to achieve scoring and to avoid suffering points and strategies are created to recover possession of the disc. As any other team sport the main objective is to make goals, using basics fundamentals to score. For the game to have progression, the disc must be released until a player receive it in the end zone, featuring a point. Despite some peculiarities of being a game without physical contact, their basic fundamentals resemble to other court games, and consequently the strategies adopted in Frisbee were adapted from other modalities. Once, there are few studies about the dynamics of the game and about the performance of the players that could be used to improve team performance in Ultimate Frisbee. The aim of this work was to analyze the reliability and validity of technical indicators in the ultimate Frisbee.

METHODS
A survey was applied to 5 experts in Ultimate Frisbee with an experience of 5 years at least in the sport as a player or a coach. This survey aimed to validate technical indicators for game fundaments in a way to standardize the language between experts and no experts. The results of the survey were used by group of sports experts to elaborate a protocol of variables to be analyzed and validated the methodology for game analysis of some basic technical indicators. Therefore, three evaluators were chosen between the group of sports experts (n= 9). The validation protocol was divided in 2 days. First day, the protocol was discussed between the experts until there was no doubt about the technical indicators that will be used. After the discussion, the protocol was applied by the three elected evaluators. Dvideo system (Figueroa, 2003), was used for to game analysis. In the first session 5500 frames of a world championship game were used to evaluate the technical indicators standardized by the experts. The frequency of analyses was 7,5 Hz. The standardized technical indicators chosen were 14 and include the pull, complete pass, backhand, forehand, hammer, incomplete pass by interception or error, height of reception (upper head; torso; lower), type of reception (pancake, frontal, one hand), diving (bid or layout) and assistance. In the second day, the evaluators individually measured another game of the world championship 2015 to test the reliability and validity of the measurements between evaluators. This time they measured 9000 frames. The results of the technical indicators of the 3 evaluators were compared using the Kappa Cohen Test. After 1 month the same 3 evaluators were invited to measure the same game and the same 9000 frames using the same protocol, at this time the aim was to evaluate the reliability and validity of the intra subjects measure. For the comparison we used the Kappa Cohen Test again.

RESULTS
The results show that during the game analysis we had 4 pulls and 3 goals, the USA team had 38 complete passes, 5 incomplete passes, considering that 27 were backhand and 16 forehand, against the Great Britain team that had 30 complete passes, 7 incomplete passes, considering that 21 were backhand, 15 forehand and 1 hammer. The score was 3x0 for USA. The reliability of the observations between evaluators
were tested using the Kappa Cohen Test. The test was conducted in pairs for all evaluators and the measurement of agreement was 0.867 (±0.031). The results of the first measurement (test) were compared with the 1-month later measurement (retest) for reliability for the 3 evaluators as shown on the tables 1, 2 and 3.

Evaluator 1: test x retest

<table>
<thead>
<tr>
<th>Symmetric Measures</th>
<th>Value</th>
<th>Asymp. Std. Error*</th>
<th>Approx. Tb</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure of Agreement</td>
<td>Kappa</td>
<td>.961</td>
<td>.013</td>
<td>33.323</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td></td>
<td>254</td>
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<td></td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Evaluator 2: test x retest

<table>
<thead>
<tr>
<th>Symmetric Measures</th>
<th>Value</th>
<th>Asymp. Std. Error*</th>
<th>Approx. Tb</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure of Agreement</td>
<td>Kappa</td>
<td>.852</td>
<td>.026</td>
<td>28.523</td>
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<td>N of Valid Cases</td>
<td></td>
<td>232</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Evaluator 3: test x retest

<table>
<thead>
<tr>
<th>Symmetric Measures</th>
<th>Value</th>
<th>Asymp. Std. Error*</th>
<th>Approx. Tb</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure of Agreement</td>
<td>Kappa</td>
<td>.806</td>
<td>.028</td>
<td>27.999</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td></td>
<td>239</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The interpretation of the kappa value by Altman (1991) shows that values between 0.81-1.00 are considerable almost perfect agreement. Therefore, in both case, the Kappa Cohen values for comparison between evaluators and intra evaluators were very high, showing that the chosen protocol can be applied to evaluate the technical indicators of the Ultimate Frisbee.

DISCUSSION

The value of agreement found in this study shows that the technical indicators chosen were very strong to define some variables that can be affected by evaluators subjective measurement in the system. Indicating that the chosen protocol was very well set up for the sport (Ultimate Frisbee) with the participation of experts and sports scientist. The methodology applied in this study...
demonstrated a good reliability and validity to measure technical indicators in this event. With this results for reliability the game analysis based on the previous technical indicators chosen can be performed for a whole game, providing a powerful tool for evaluation of the technical indicators of a match. Consequently, a greater understanding of the game can be improved using this protocol by different sports scientist and sports informatics.

CONCLUSION
This kind of data can be used to understand the dynamics of the game and improve the knowledge behind the ultimate Frisbee. Further studies should be conducted to evaluate a whole match, and compare the results between teams. Those results need to be combined with other potential application in sports and exercise.

REFERENCES:
Analytical Method for Evaluating Offensive Teams’ Performance Based on Sequences of Actions in Basketball

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In invasion team sports, strategy can be inferred through the analysis of recurrent tactical patterns performed during the game. In basketball, offensive actions are connected during a ball possession producing distinct sequences, with particular features that may directly affect the offense outcome. These sequences of actions can be assessed to characterize a team strategy and its efficiency. The present study aimed to develop a method to evaluate sequences of offensive actions in basketball. Reliability and objectivity of the criteria applied for defining the different sequences of actions indicated adequate consistency (Kappa test > 0.78). Results evidenced that the proposed method was able to discriminate teams based on the registered differences of their strategy features.

**KEYWORDS:** strategy inference, dynamical analysis, game patterns, concatenation.
INTRODUCTION

In basketball, the ability of a team to act collectively may increase the chances of overcoming its opponent (Cannon-Bowers; Bowers, 2006). Specifically, the coordination of offensive actions allows players to enhance plays diversity, generating more uncertainty to the opponent. Specific offensive actions were organized in equivalence classes denominated Space Creation Dynamics (SCDs) (Lamas et al, 2011). The SCDs comprehend the following actions: pick, screen, 1on1 in the perimeter, 1x1 in the post and cut. Other actions can also be considered if classes are decomposed, for instance, handoff, spot-up and dime in. A main limitation regarding the use of SCDs for game analysis is the fact that they do not occur isolatedly, but in sequences through the ball possession. In each sequence, actions can be performed simultaneously or concatenated. In an example, the offensive system flex offense encompasses two screens performed in sequence, in which the player setting the first screen is the one receiving the screen in the next action. This example shows that different SCDs sequences can change the structure of a team offense and directly influence cooperation and opposition in basketball. Therefore, the purpose of the present study was to validate an analytical method to assess the possibilities of sequencing SCDs.

METHODS

Classes of SCDs sequences

The classes of SCDs sequences defined were: i) synchronization; ii) independent concatenation; iii) dependent concatenation. Synchronization refers to two or more SCDs performed simultaneously (e.g. a pick performed at the same time of a screen). Independent concatenation refers to two SCDs connected without influence of the first action in the second one (e.g. a pick followed by a screen, where the second action just starts when the first ended). Finally, dependent concatenation refers to two SCDs connected and influencing one another, in which the start of the second action occurs before the first ends. Additionally, in this case there should have the participation of at least one player in both concatenated actions (e.g. screen to screener).

Validation procedures

Validation followed the steps adopted by Fonseca, Salles and Parente (2008). Two expert basketball coaches participated as volunteers in this procedure. Kappa coefficient was calculated and the levels of agreement intra- and inter-observer were compared between day1 x day2, day1 x day3 and day2 x day3. Assessments were performed with at least 7 days apart. This test consisted in classifying the SCD sequences in every ball possession of two NBA teams for two quarters. After reliability procedures, the resultant classes of SCDs sequences were applied in the analysis of basketball games.

Experimental approach

The sample was composed of 28 games from the 2013-2014 NBA playoffs. Confronts selected for this study were conference finals (Spurs vs. Thunder and Pacers vs. Heat) and the NBA Final (Spurs vs. Heat). SCDs sequences were analyzed considering the respective outcome of the ball possession. Two and three points scored shots and received fouls were considered as positive outcomes while two and three points missed shots and turnovers were considered as negative outcomes.

RESULTS

Intra- and inter-observer tests presented high levels of agreement (Kappa test >0.78) indicating the high consistency of developed criteria to determine the different types of SCDs sequences.

We systematized 27 possibilities of dependent concatenations. The results of game analysis indicated predominance of independent concatenations over dependent (76% vs. 24%). Among the four teams analyzed, we could not find any SCD synchronization. Despite the low recurrence, dependent concatenations presented higher efficiency considering the offense outcome when compared with independent concatenations (Table 1). Table 1 shows superiority of dependent concatenation “staggered screen” compared to the results obtained through the independent concatenation “screen-screen”, except for the confront of Heat offense versus Pacers defense (0.33 vs. 0.60).
Staggered screen refers to the actions in which the same player receives two screens in sequence, while in the independent concatenation “screen-screen” two screens are set without relation between them.

### Table 1
Efficiency of SCDs concatenation types.

<table>
<thead>
<tr>
<th>Offense Team</th>
<th>Defense Team</th>
<th>Dependent Conc. (Staggered Screen) (% efficiency)</th>
<th>Independent Conc. (Screen - Screen) (% efficiency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacers</td>
<td>Heat</td>
<td>0.36</td>
<td>0.00</td>
</tr>
<tr>
<td>Spurs</td>
<td>Heat</td>
<td>0.33</td>
<td>0.13</td>
</tr>
<tr>
<td>Spurs</td>
<td>Thunder</td>
<td>0.64</td>
<td>0.50</td>
</tr>
<tr>
<td>Heat</td>
<td>Spurs</td>
<td>0.55</td>
<td>0.33</td>
</tr>
<tr>
<td>Heat</td>
<td>Pacers</td>
<td>0.33</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Some dependent concatenations were performed by only one team and contributed to emphasize differences on teams strategy (Panel 1). For instance, Indiana Pacers was the only team to present the dependent concatenation “pick to screen receiver”, in which the same player that receives a screen receives a pick from another teammate in the next action (Panel 1A). Miami Heat presented the concatenation “receive screen and pick” in which the player who receives a screen in the first action immediately moves to set a pick to another teammate (Panel 1B). San Antonio Spurs was the team with greater diversity of patterns. This team presented dependent concatenations involving the SCD’s pick, screen and handoff such as: a) “staggered pick”, the player with ball receives two picks in sequence (Panel 1C upper); b) “sequential screens” involves two actions in which the same player who set a screen in the first action performed another screen in the second action (Panel 1C middle); c) “handoff to screen receiver”, the ball player performs a handoff ball pass to his teammate who just received a screen in the previous action (Panel 1C bottom).
The Oklahoma City Thunder did not present any dependent concatenation during the games.

**DISCUSSION**

The main result of this study was that the defined criteria resulted in categories of SCD synchronization, independent and dependent concatenations, allowing to discriminating teams strategies. These categories represent a specification for basketball of small group of actions defined in a theoretical model of strategy proposed elsewhere (Lamas et al., 2014). Categories were systematized only for dependent concatenation due to the smaller number of possibilities for this type of sequencing and the fact that each category contains specificities that may change the offensive structure of the teams.

SCDs concatenation categories overcome some limitations of previous studies that classified the teams considering SCDs isolatedly (Lamas et al, 2011), without considering the sequential structure of SCDs in a single ball possession.

In respect to the application of the presented classes to the analysis of basketball games, there was a prevalence of independent concatenations over the dependent concatenations, although dependent concatenations presented higher frequency of related positive outcomes. A possible explanation for higher success rates after de-
dependent concatenations is the fact that the delay caused on the defender position in the first action is augmented in the next action, resulting in more space for the offensive player finishes his play with lower contestation. Additionally, a possible reason for the lower recurrence of dependent concatenations is the higher complexity of this type of concatenation, with greater demands of coordination and timing between team players.

**CONCLUSION**

The SCD concatenation classes demonstrated to be useful to infer team strategy based on the offensive team patterns. This may be helpful for coaches design and improve their teams strategy, identify the most efficient offensive patterns and define more accurately the contents of training sessions based on these analysis.

**REFERENCES**


SPORTS BIOMECHANICS
The purpose of the current study was to evaluate the relationship between shoulder girdle muscular activation and hit distribution patterns in archery. 6 female (age: 16.66±3.44 yrs; training age: 5.88±2.92 yrs) and 10 male (age: 22.33±12.95 yrs; training age: 4.11±2.80 yrs) subjects participated in the study. Each archer shot 12 arrows to a target at 30m distance. Bipolar surface EMG recordings were taken from anterior (DF), middle (DM) and posterior (DP) portions of m. deltoideus, and from upper (TU) and middle (TM) part of m. trapezius of both the bow and drawing arm. The target face was segmented into 4 distinct target zones and muscle activation was identified according to the actual target zone hit. iEMG % values of the bow arm muscles identified for the time period before the fall of the clicker, DM activation was higher for hits in zone 3 than in zone 4. TM activation value was higher for hits in zone 4 than in zones 1, 2, and 3 during the fall of the clicker. In the period of time between one second before and the moment of fall of the clicker, TU muscle activation in drawing arm was significantly higher for hits in the Zone 1 and Zone 4 than in Zone 2.

KEYWORDS: archery, muscular activation, hit distribution pattern.
INTRODUCTION
Mann & Littke (1989) described archery as a comparatively static sport requiring strength and endurance of the upper body, in particular the forearm and shoulder girdle. Drawing arm action is responsible for the draw and release while the archers hold the bow in the direction of the target with an extended bowarm (Leroyer et al., 1993). Shoulder-girdle muscles are contracted concentrically during the drawing phase. When an archer reaches full draw or aiming position, the mentioned musculature contract isometrically until just before the fall of the clicker (Leroyer et al., 1993). The release phase must be well balanced and highly reproducible to achieve commendable results in a competition (Nishizono et al., 1984). The bow arm is responsible for pushing the bow and adjusting the placement of the sight on the target by resisting the force from the drawing arm when we consider the collective movement of archery shooting (Nishizono et al., 1984; Soylu et al., 2006).

An end consists of 3 to 6 arrows, which are typically registered without information on the location of each arrow (Ertan et al., 2005). The arrows are only scored from highest to lowest representing the total distance from the target center leading to limited analysis possibilities. Distribution patterns of the hits on the target face leading to limited analysis possibilities. Distribution patterns of the hits on the target face allow for identification and analysis of spatial patterns (Callaway & Broomfield, 2012). Callaway and Broomfield (2012) validated an input method for these hits to analyse underlying continuous spatial distributions (Johnson, 2001). Earlier studies have defined specific forearm muscular activation patterns in relation to the performance levels of archers. However, all these studies were just using the total scores of archers included into the given studies. They did not relate muscular activation strategies to hit distribution patterns on the archery target. So the purpose of the current study was i. to establish hit distribution patterns on the target and ii. to evaluate the relationship between shoulder girdle muscular activation and hit distribution.

METHODS
6 female (age: 16.66±3.44 yrs; training age: 5.88±2.92 yrs) and 10 male (age: 22.33±12.95 yrs; training age: 4.11±2.80 yrs) subjects participated in the study. Each of the archers shot 12 arrows in a competition like rhythm to a target positioned 30 m from the shooting line. Bipolar electromyographic (EMG) recordings were taken from m. deltoideus frontal (DF), medial (DM) and posterior (DP) part, as well as m. trapezius upper (TU) and middle (TM) part of both the bow and drawing arm respectively. EMG activity of the muscles was recorded together with a pulse synchronized with the clicker snap. Raw EMG recordings from 1s before and after the clicker pulse were rectified, integrated, and normalized.

iEMG values obtained from drawing arm and bow arm muscles were assigned and distributed to four target zones according to x,y coordinates separating the target face into a left and right side and an upper and lower area (Fig. 1a). Differences between iEMG values related to hits in respect to the different zones were analyzed by using ANOVA.

Independent samples t-tests were applied for comparisons of muscle activation related to target hits below and above the horizontal x-axis (fig. 1b) and the hits left or right of the vertical y-axis (fig 1c).

Figure 1
Location of every arrow hit on the target face according to zones.
RESULTS

192 shots and their EMG recordings from 16 archers have been subdivided into four zones according to the location on the target.

The comparison of the iEMG data related to the bow arm corresponding to upper and lower zone hits revealed significantly different muscle activation for TM and DF for the period after the fall of the clicker. iEMG values of TM were higher for hits in the lower zone (44,556±13,572 mVs) than for hits in the upper zone (40,360±11,919 mVs) whereas for hits in the upper target zone a statistically higher muscle activity of DF (60,102±11,941 mV) was identified compared to lower zone hits (55,082±11,446 mVs).

According to drawing arm muscle activities iEMG data of DP muscle were statistically higher for hits in the upper target zone (77,268±5,568 mVs) than for lower zone (75,144±6,742 mVs) for the time period before the fall of clicker whereas after the fall of the clicker, iEMG values of TM muscle were higher for hits in the upper zone (50,262±15,132 mVs), than in the lower zone (44,439±11,545 mV).

DISCUSSION

Different positions of the hits on the target are associated with different contraction patterns of the shoulder muscles. Hit distribution patterns can be related to particular muscular involvement strategies. It can be that speculated that specific training regimes with direct feedback of muscle activation are able to change contraction-relaxation coupling which then directly influences hit accuracy and target precision.

REFERENCES


The purpose of the study was to assess the effect of 2D kinematical selected variables on sprint start with Sprinting Performance of Novice Athletes. Six (3 National and 3 State level) athletes of Sports Authority of India, Guwahati has been selected for this study. The mean (M) and standard deviation (SD) of sprinters were age (17.44, 1.55), height (1.74 m, .84 m), weight (62.25 kg, 4.55), arm length (65.00 cm, 3.72) and leg length (96.35 cm, 2.71). Biokin-2D motion analysis system V4.5 can be used for acquiring two-dimensional kinematical data/variables on sprint start with Sprinting Performance. For the purpose of kinematic analysis a standard motion driven camera which frequency of the camera was 60 frame/second i.e. handy camera of Sony Company were used. The sequence of photographic was taken under controlled condition. The distance of the camera from the athletes was 12 mts away and was fixed at 1.2-meter height. The result was found that National and State level athletes significant difference in there, Trajectory Knee, Trajectory Ankle, Displacement Knee, Displacement Ankle, Linear Velocity Knee, Linear Velocity Ankle and Linear Acceleration Ankle whereas insignificant difference was found between National and State level athletes in their Linear Acceleration Knee joint on sprint start with sprinting performance. For all the Statistical test the level of significance was set at p<0.05.

**KEYWORDS:** 2Dimensional Kinematic Analysis, Sprinting Ability, Sprinting Performance, Novice Athletes
INTRODUCTION
The most powerful nations of the world namely USA, Russia, France, Australia, China etc. are strong enough not only in World Economics, Army Strength or in science technology but they are also advanced in the field of sports, therefore it is quite apparent that to exist strongly in world map nation has to be advanced in the field of sports also. To achieve the same adoption of new techniques and methodology is highly required in Sports Sciences and Physical Education. Sciences of applied mechanism are fulfilling these demands of high technological knowledge for the enhancement of performance in the field of sports. Sprinting includes a rapid acceleration phase followed by a maintenance pace (constant velocity). During the early stage of sprinting, the runners have their upper body tilted forward in order to get ground reaction forces more horizontally. Sprinters, whose events are based on power, differ greatly from more economical distance runners in both physical appearance and running biomechanics. Sprinting is product of stride length and frequency of stride that emphasizes speed and power. Sprinting events are divided into three main phases: acceleration, maintenance, and deceleration. The acceleration phase is characterized by aggressive, powerful running form used to build the momentum needed to overcome inertia and achieve maximum velocity. In the last few decades, much has been added to ours scientific knowledge of biomechanics, a science concerned with the internal and external forces acting on the human body and the effects produced by these forces and activity of the muscles. At the highest levels of sports in which techniques play a major role, improvement comes so often from careful attention to detail that no coach can afford to leave these details to chance or guesswork. For such coaches knowledge of biomechanics might be regarded as essential.

METHODS
Selection of Subjects
A total Six (3 National and 3 State level) athletes of Sports Authority of India, Guwahati has been selected for this study. The mean (M) and standard deviation (SD) of sprinters were age (17.44, 1.55), height (1.74 m, .84 m), weight (62.25 kg, 4.55), arm length (65.00 cm, 3.72) and leg length (96.35 cm, 2.71).

Collection of Data
The data collected by the help of Biokin-2D motion analysis system V4.5 method and the sprinting performance of the subject during sprint start in athletic.

Filming Procedure
Biokin-2D motion analysis system V4.5 can be used for acquiring two-dimensional kinematical data/variables on Sprint Start with Sprinting Performance. For the purpose of kinematic analysis a standard motion driven camera which frequency of the camera was 60 frame/second i.e. handy camera of Sony Company was used. The sequence of photographic was taken under controlled condition. The distance of the camera from the athletes was 12 mts away and was fixed at 1.2 meter height. The performance of sprinters were measured manually hand timing with stopwatch for each subject. Before data acquisition subjects were asked to go for complete warm-up for at least 15 minutes by stretching all major muscle groups for better performing the sprint start. After warming up all the athletes have to perform 100 meters sprint and the time recorded in 1/1000 of the seconds for each athlete was selected for further analysis.

Data Analysis
The data was collected with the help of digital photography, the photography were analysed (1/1000 sec) by standard analysis method. With the help of Biokin-2D motion analysis computer software we can measure the dimension of each photograph with the help of which various kinematical variables were calculated during sprint start.
Statistical Analysis
To determine the effect of selected kinematic variables on sprint start with the sprinting performance of subjects. The data of this study was analyzed by using a t-test to infer the difference between national and state level Sprinters. The level of significance was 0.05.

RESULTS
The purpose of this study was to determine kinematic difference between on sprint start with sprinting performance of sprinters of Sports Authority of India, Guwahati and find out those variables which are given positive contribution in sprinting ability and sprinting performance. The results and analysis of the data of the study have been presented on six sprinters. Independent t–test were used to find out differences and relationship between sprint start and sprinting performance.

As indicated in Table-1 National level athletes have longer trajectory Knee Joint (1.88 m) and Trajectory Ankle Joint (2.28) as compare to state level athletes (1.81 m) and (1.88 m), that might be the reason the Linear Velocity Knee (1.93 m/s), Linear Velocity Ankle (2.32 m/s), Linear Acceleration Knee (6.86 m/s²) and Linear Acceleration Ankle (10.84 m/s²) is greater than state level (1.32 m), (1.37 m), (0.49 m/s²) and (1.45 m/s²) athletes. The Displacement of Knee joint and Displacement of ankle joint in grater in National level athletes respectively.

Table 1
Descriptive Statistics of selected kinematical parameters

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean/ SD</th>
<th>TJK (m)</th>
<th>TJA (M)</th>
<th>DPK (M)</th>
<th>DDA (M)</th>
<th>LVK (M/s)</th>
<th>LVA (M/s)</th>
<th>LAK (m/s²)</th>
<th>LAA (m/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Level</td>
<td>Mean</td>
<td>1.81</td>
<td>1.88</td>
<td>0.033</td>
<td>0.035</td>
<td>1.32</td>
<td>1.37</td>
<td>0.49</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.52</td>
<td>0.59</td>
<td>0.09</td>
<td>0.09</td>
<td>2.32</td>
<td>2.17</td>
<td>17.13</td>
<td>30.11</td>
</tr>
<tr>
<td>National Level</td>
<td>Mean</td>
<td>1.88</td>
<td>2.28</td>
<td>0.035</td>
<td>0.003</td>
<td>1.93</td>
<td>2.32</td>
<td>6.86</td>
<td>10.84</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.55</td>
<td>0.46</td>
<td>0.22</td>
<td>0.12</td>
<td>2.86</td>
<td>2.82</td>
<td>24.31</td>
<td>37.16</td>
</tr>
</tbody>
</table>

TJK=Trajectory Knee, TJA= Trajectory Ankle, DPK= Displacement Knee, DDA= Displacement Ankle, LVK= Linear Velocity Knee, LVA= Linear Velocity Ankle, LAK= Linear Acceleration Knee, LAA= Linear Acceleration Ankle.
As showed in the Table 2 there were significant differences found between National level and State level athletes in their Trajectory Knee, Trajectory Ankle, Displacement Knee, Displacement Ankle, Linear Velocity Knee, Linear Velocity Ankle and Linear Acceleration Ankle whereas insignificant difference was found between National level and State level athletes in their Linear Acceleration Knee joint.

**DISCUSSION**

The main purpose of this study was to find out kinematical differences between National level and State level athletes of Sports Authority of India, Guwahati, Assam. The sequential photography technique was employed to record the kinematic variables. Result show that Trajectory, displacement linear velocity, linear acceleration of knee and ankle joints of the sprinters was better position in quantitative evaluation. From the photographs, the stick figures were prepared by using Joint-point Method, and various kinematic variables were obtained at the moment start the sprinting.

The length and duration of acceleration was unwavering by the starting position of the knee and when the body is almost fully stretched. In order to attain quick acceleration sprinter adopts the correct knee bent angle during start at the beginning of the acceleration. In the case of National level and State level sprinters position of set was correct would have helped them to attain lower and lesser Trajectory, improved displacement and good velocity of the knee and ankle joint.

The National level athletes have longer trajectory Knee Joint (1.88 m) and Trajectory Ankle Joint (2.28) as compare to state level athletes (1.81 m) and (1.88 m), that might be the reason the Linear Velocity Knee (1.93 m/s), Linear Velocity Ankle (2.32 m/s), Linear Acceleration Knee (6.86 m/s²) and Linear Acceleration Ankle (10.84 m/s²) is greater than state level (1.32 m), (1.37 m), (0.49 m/s²) and (1.45m/s²) athletes. The Displacement of Knee joint and Displacement of ankle joint in greater in National level athletes respectively.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Calculated 't' value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TJK</td>
<td>3.23*</td>
</tr>
<tr>
<td>TJA</td>
<td>5.71*</td>
</tr>
<tr>
<td>DPK</td>
<td>4.34*</td>
</tr>
<tr>
<td>DDA</td>
<td>3.59*</td>
</tr>
<tr>
<td>LVK</td>
<td>3.13*</td>
</tr>
<tr>
<td>LVA</td>
<td>3.34*</td>
</tr>
<tr>
<td>LAK</td>
<td>2.45</td>
</tr>
<tr>
<td>LAA</td>
<td>3.53*</td>
</tr>
</tbody>
</table>

*Significance at 0.05 level of confidence with 4 df; Tab ‘t’ = 2.77
ACKNOWLEDGEMENT

Authors would like to thank Lakshmibai National Institute of Physical Education (India) for providing assistance in collecting the relevant information for undertaking quality research.

REFERENCES


The present study describes the differences between how a ball bounces on a putting mat and a rubber surface. For each surface, thirty putts struck with desirable launch conditions were analysed by a Quintic ball roll system. Bouncing was greater and less random on the putting mat. A greater increase in ball roll in between bounces on the rubber surface is indicative of its greater coefficient of kinetic friction. It seems that the coefficient of kinetic friction may decrease with speed, helping to explain why putts that bounce are more difficult to control for distance.

**KEYWORDS:** Golf, Putting, Video Analysis, Coefficient of Kinetic Friction
INTRODUCTION

It is widely accepted that a putted golf ball will exhibit both sliding (or skidding) motion. Minimising the sliding distance is thought to make a putt easier to control for distance (Pope, James, Wood and Henrikson, 2014). Most putters are manufactured with a standard loft of 3-5°, however, experts in the field of putting recommend that the launch angle of a putt (the angle at which the ball leaves the putter face with respect to the surface) should not exceed 2° (Quintic) in order to minimise bouncing. Despite previous studies referring to small bounces occurring during a putt (Lindsay, 2003), especially amongst less skilled golfers (Delay, Nougier, Orliaguet and Coello, 1997), studies have failed to quantify these bounces. However, to the author’s knowledge, little or no research has investigated in any detail the bouncing during the initial phases of a golf putt. The present study will assess how much bouncing is present during a golf putt and whether this is effected by different surface properties.

METHODS

Golf putts performed on both a putting mat and a rubber surface were analysed with a Quintic Ball Roll system. This system is effectively a launch monitor for putting, consisting of a high-speed camera (360 frames per second) mounted upon a bed of LED lights. Following a simple calibration procedure, the camera tracks 3 ink spots placed on the golf ball for the first 16 inches of the putt, providing angular data and the centre of the ball is tracked for ball speed and height data. Frame-by-frame values for ball roll (revolutions per minute (rpm)), linear velocity (miles per hour (mph)) and vertical bounce (inches) were analysed.

The recommendations suggest that a putt should have an initial launch angle between 0.75° and 2°, an “initial ball roll” value not exceeding 40 rpm and no greater than 20 rpm of sidespin imparted on the ball. Ball roll, linear velocity and vertical bounce data was transformed into an Excel spreadsheet. The values for the vertical bounce and speed were multiplied by 1000 and 100, respectively when plotting a graph (see figure 1).

When the ball is in the air, as shown by the vertical bounce, a single value for ball roll was taken which fell somewhere in the middle of the data points, as shown by the dashed line, as physics suggests that when the ball is bouncing and skidding, the angular motion of the golf ball should remain almost constant when the ball is airborne. This allowed the difference in ball roll due to the first bounce and second bounce to be determined. The initial increase in ball roll was dependent on how the ball was struck. The height of each bounce was calculated from the maximum and minimum value of each on the graph. Analysed for each putt performed on both surfaces was the height of the first three bounces (however not for putts performed on the rubber surface), and the increments in ball rolls resulting in the contact periods in between bounces.

![Figure 1](attachment:image_url)

*Figure 1*

Typical frame-by-frame values of ball roll, linear speed and vertical bounce for a putt performed on the putting mat.
RESULTS

Figure 2 shows the mean frame-by-frame values for vertical bounce, linear velocity and ball roll on the putting mat and rubber surfaces. On the putting mat, the mean bounce heights, 0.082”, 0.060” and 0.040” were found to be significantly different from one another (P<0.01). For all 30 putts, the increase in ball roll between bounces 1 and 2 was greater than that between bounces 2 and 3, with a mean difference of 21.36 ± 10.61 rpm, which was statistically significant (t=11.02, P=0.000). The average bounce pattern displayed on putts struck on the rubber was much smaller and more random compared to that of the valid putts struck on the putting mat. The heights of the bounce were not recorded as they were deemed negligible. Seventeen of the 30 putts performed on rubber displayed a greater increase in ball roll between bounces 1 and 2 compared to between bounces 2 and 3, with a mean difference of 12.02 ± 43.30 rpm, which was statistically insignificant (t=1.52, P=0.139).

There was no statistical difference in impact velocities between putts struck on either surface (mean difference=0.05mph, t=-0.841, P=0.404) nor launch angles (mean difference=0.01°, Mann-Whitney U=437.5, P=0.429). Ball roll increased more between bounces 1 and 2 on the rubber surface than the putting matt (mean difference=131.48RPM, Mann-Whitney U=0.000, P=0.000) and also between bounces 2 and 3 (mean difference=140.82RPM, Mann-Whitney U=0.000, P=0.000).

DISCUSSION

Although the mean bounce heights of the 30 valid putts performed on the putt mat were all found to be significantly different from one another (P<0.000), the heights of each bounce are very small. The ball will therefore descend onto the surface with an angle of incidence small enough to assume that it is sliding throughout the bounce and bounces with a horizontal COR of less than zero (Cross, 2002). Figure 2 shows that ball roll continues to rise for a period after the third bounce until it reaches a plateau. The ball can be said to enter a skidding phase after the initial bouncing where the ball is in constant contact with the surface. As the ball is assumed to be sliding throughout its bounce, then the friction force acting on the ball is the product of its normal gravitational force and the coefficient of kinetic friction (µk). The frictional force acting on the ball results in a torque which causes angular motion.

![Figure 2](image-url)

**Figure 2**

Mean frame-by-frame values of ball roll and vertical bounce on both putting mat and rubber surfaces.
A constant amount of frictional force would be assumed to act on the ball in between bounces, however, the increase in ball roll was significantly smaller after the second bounce compared to the first (P=0.00), suggesting that less friction is acting on the golf ball in between bounces 2 and 3. The size of the frictional force acting on the golf ball is dependent on the surface’s deformation, which is in turn determined by the incident angle and firmness of the surface (Penner, 2002). However, the bounces recorded in these results are so small, the incident angle and deformation of the surface can be assumed to be the same during both contact periods and thus would not influence the amount of frictional force acting on the golf ball. Instead, these results could be explained by the fact that the μk of a smooth surface sliding along an elastically soft material increases with sliding speed (Cross, 2005) and so it’s possible that the μk between the putt mat and golf ball may have been less between bounces 2 and 3 where the sliding speed had dropped slightly.

Putts performed on the rubber surface experienced 3 small bounces that were smaller in both height and duration compared to those on the putting mat. These differences can’t be attributed to different launch conditions, as both impact velocity and launch angle were found to be insignificantly different to those of the puts on the putt mat (P=0.404 and 0.429, respectively) so must be a result of the surface. The rubber surface was a lot firmer than the putting mat and therefore it is unlikely that the weight of the golf ball when stationary was enough to form any indentation in the surface as it would with the putting mat. It’s possible that this small indentation in the putting mat’s surface could act as a “ramp” that the ball will be launched out of which could explain why higher bounces were experienced on the putting mat despite indifferent launch conditions.

As the rubber surface is less likely to deform during the bounces, a smaller contact area will be present compared to when the putting mat surface deforms. A golf ball is covered in small dimples designed to reduce drag on full shots, and these could also be a reason why a more random bouncing pattern occurred on the rubber as the ball will rebound at random angles due to the irregular surface golf ball’s dimples (Cross and Nathan, 2007). Horizontal and vertical components of the ball’s bounce will therefore be determined by the contact area, which will differ from putt-to-putt. Additionally, the rubber’s surface is designed to be highly frictional and so will be more irregular than the putting mat. The ball will therefore impact the rubber at different areas and this could attribute to the random bouncing. The increase in ball roll, both in between bounces 1 and 2 and bounces 2 and 3, was significantly greater on the rubber surface (P=0.00 for both). Again, the ball can be assumed to be sliding throughout the bounce. As there are 2 distinct rises in ball roll (figure 2), the ball cannot be said to have begun to roll or entered “biting” mode during the contact period between bounces 1 and 2 (Cross, 2002) as the ball roll curve does not plateau until after the third bounce. A greater value of μk between the golf ball and surface results in a greater frictional force acting on the ball in between each bounce, and so the ball gains angular motion at a much greater rate. In fact, after the third bounce, the ball has gained so much angular momentum that a very short sliding phase of the putt occurs before the ball roll curve plateaus signifying that the ball is rolling. The increase in ball roll between bounces 1 and 2 and bounces 2 and 3, were not found to be significantly different from one another (P=0.139). This contradicts the findings from the putt mat and implies that similar amounts of frictional force acted on the ball during both contact periods. Cross’s (2005) findings were for a tennis ball cloth, and so the dissimilar surface properties between this and the rubber is likely to be the reason why the theory behind his results did not apply in this situation.

CONCLUSIONS

Previous literature in the area of golf putting has acknowledged that bouncing does occur, but suggests that this is due to poor technique. However, this study shows that even putts that are struck with desirable launch conditions experienced bouncing throughout the initial stages of the putt. Rather than dividing a golf putt into just two phases; a skidding or sliding phase and a true rolling phase, this study proposes that there are actually three phases of a golf putt: Phase 1 – Bounce-slide. The ball leaves the surface and slides throughout its bounces. Phase 2 – Pure slide. The ball is in constant contact with the surface...
and ball roll rises steadily. Phase 3 – Pure roll. Ball roll reaches its maximum value and plateaus. It seems that the amount of friction acting on the ball may be dependent on the linear velocity of the golf ball as it slides throughout its bounce. If this is the case, it provides a sound explanation as to why putts that bounce are difficult to judge for pace. The duration of these 3 phases will be determined by the putt’s launch conditions and also the surface properties. On a firmer surface such as the rubber used in this study, a golf ball seems to bounce less and with a more random pattern. Using a surface such as rubber is an effective way of demonstrating that a surface with greater $\mu_k$ creates a greater increase in ball roll when the ball is in contact with the surface. This results in a shorter pure slide phase and so pure roll occurs earlier.

REFERENCES
This study investigated and compared the sensorimotor coordination and time movement ability for badminton players and footballers. The objective of this study was to understand the psychological construct of the selected sport group for which 100 male sportspersons (50 each in badminton and football) in the age group 18-25 years with a mean & SD of 20.05 ± 2.04 were randomly selected. It is hypothesized that (i) no difference would be seen between both the groups in sensorimotor coordination; (ii) badminton players time movement anticipation would be faster than footballers. For measuring sensorimotor coordination and time movement anticipation, Vienna test system (VTS), a computerized psychological assessment tool was used. Independent ‘t’ test was applied at 0.05 level of significance. The results revealed that there is statistically significant difference in the mean deviation time medium fast (MDTMF), between badminton players and footballers as the obtained ‘t’ value of 2.02 is greater than the required value of 1.98 at 98df. No statistically significant difference was observed in any other parameter; however the mean score of badminton players were better in comparison to footballers in the selected parameter. These results suggest that the badminton players have faster time movement anticipation as hypothesized. This may be owing to the nature of the sport.

**KEYWORDS:** sensorimotor coordination, determination test, VTS
INTRODUCTION
Successful performance in sport requires not only efficient execution of motor behaviour but also a high level of perceptual ability (Dogan, 2009). The human sensorimotor system is very complex. Cognitive expertise can be divided into two sub domains: tactical knowledge, which involves the ability to determine not only what strategy is most appropriate in a given situation but also whether the strategy can be successfully executed, and perceptual skills, which consist of pattern recognition, anticipatory cue extraction and use (Baláková, Boschek & Skalíková, 2015).

Modern badminton involves the domination of a defensive game, which is very quick and aggressive. This requires not only an excellent physical condition and overall coordination level, but also specific coordinative motor skills, which may be regarded as psychomotor predispositions as well (Poliszczuk & Mosakowska, 2009). Open-skill sports, such as football, are performed in constantly changing environments. Athletes must be able to move in a variety of ways and adapt to rapidly changing situations taking into consideration the various moves and movements of their teammates and further also that of their opponents. Williams (2000) and Vickers (2007) similarly stated that athletes should be able to anticipate what is most important in the environments in which they play. Moreover, athletes are expected to attend to critical cues, concentrate at the appropriate moments, retrieve necessary information from memory at the proper time, solve problems when they arise, and, ultimately, make a correct decision under time constraints.

A high level of perceptual skills may also indirectly contribute to the improvement of time movement anticipation, which is a very important element of badminton competition. High class competitors playing racket sports are characterized by a high level of anticipation skill, allowing them to predict the opposing players’ actions (Poliszczuk & Mosakowska, 2009). It is hypothesized that (i) no difference would be seen between both the group in sensorimotor coordination; (ii) badminton players time movement anticipation would be faster than footballers.

METHODS
To serve the purpose of the investigation, one hundred university level male players of badminton and football in the age group of 18 - 25 years with a mean & SD of 20.05 ± 2.04 were randomly selected for the study. The badminton players mean and SD of age was 22.28 ± 1.68 and for footballers it was 22.42 ± 1.73.

The variables along with the test form selected for this study, were as follows:

a. Sensorimotor Coordination (SMK)
Test form used is S1. The main sub variables for calculation are time in ideal range (TIIR) measured in percentage. It represents the percent of time the circular segment was in the ideal range.

b. Time Movement Anticipation (ZBA)
Test form used is S5. The main sub variables for calculation are mean deviation time (MDT), mean deviation time slow (MDTS), mean deviation time medium fast (MDTMF), mean deviation time fast (MDTF).

The variables were measured using Vienna test system (VTS), a computerized system that is able to analyze many different sport psychology-related constructs. VTS was developed by Schuhfried GmbH (Moedling, Austria) as a valid and reliable tool for psychological assessment (Schuhfried, 2013). VTS is also widely used by applied practitioners to conduct psychological testing in different sport settings, including the German and Austrian football associations, the Greek national basketball team, and football clubs such as OSC Lille and FC Hoffenheim (‘Sport psychological ability’, 2014) The subjects were informed about the rules and the objectives of the test, and were then given some free trials to get used to the ways of the test, before the data was collected.

RESULTS
Independent samples t-test was applied to compare the psychological variables i.e., sensorimotor coordination and determination test. Abbreviated format of the test items are mentioned in the table and explained.
Table 1
Descriptive Statistics and ‘t’ test for Badminton Players and Footballer in Selected Psychomotor Variables

<table>
<thead>
<tr>
<th>SPORT_GROUPS</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Std. Error Mean</th>
<th>t</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMK_TIIR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badminton</td>
<td>50</td>
<td>7.00</td>
<td>6.20</td>
<td>0.88</td>
<td>1.52</td>
<td>98</td>
</tr>
<tr>
<td>Football</td>
<td>50</td>
<td>5.34</td>
<td>4.62</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZBA_MDT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badminton</td>
<td>50</td>
<td>0.56</td>
<td>0.22</td>
<td>0.03</td>
<td>1.87</td>
<td>98</td>
</tr>
<tr>
<td>Football</td>
<td>50</td>
<td>0.66</td>
<td>0.28</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZBA_MDTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badminton</td>
<td>50</td>
<td>0.70</td>
<td>0.34</td>
<td>0.05</td>
<td>1.11</td>
<td>98</td>
</tr>
<tr>
<td>Football</td>
<td>50</td>
<td>0.79</td>
<td>0.49</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZBA_MDTMF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badminton</td>
<td>50</td>
<td>0.56</td>
<td>0.27</td>
<td>0.04</td>
<td>2.02*</td>
<td>98</td>
</tr>
<tr>
<td>Football</td>
<td>50</td>
<td>0.70</td>
<td>0.39</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZBA_MDTF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badminton</td>
<td>50</td>
<td>0.43</td>
<td>0.18</td>
<td>0.02</td>
<td>1.46</td>
<td>98</td>
</tr>
<tr>
<td>Football</td>
<td>50</td>
<td>0.48</td>
<td>0.16</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* > significant at t.05 (98 df) = 1.98 at 0.5 level of significance

In table 1 the obtained mean scores, SD and standard error mean of sensorimotor coordination time in ideal range (TIIR) and mean deviation time (MDT), mean deviation time slow (MDTS), mean deviation time medium fast (MDTMF), mean deviation time fast (MDTF) for badminton players and footballers have been displayed which is self explanatory. The graphical illustration of the mean scores is displayed to show a clear-cut distinction between both the groups.

Figure 1
Mean scores of Athletes’ for Selected Psychomotor Variables
The comparative statistics of independent t-test results signified that in the various sub-factors the calculated t-values of time movement anticipation _MDTMF(2.015) were more than the tabulated t value (1.98) with 98 df at 0.05 level of significance. Thus, there is a significant difference between the badminton and football players in the sub-factor of time movement anticipation.

Further, the calculated t-values in the sub-factors of sensorimotor coordination_TIIR (1.519), time movement anticipation _MDT (-1.87), time movement anticipation _MDTS (0.269) and time movement anticipation _MDTF (-1.455) were less than the tabulated t value (1.98) with 98 df at 0.05 level of significance. Thus, there is an insignificant difference between the badminton and football players in the sensorimotor coordination and in the subfactors of time movement anticipation of mean deviation time (MDT), mean deviation time slow (MDTS), mean deviation time fast (MDTF).

As compared with the norm sample (having mean scores of 8.33) for sensorimotor coordination for the educational level 5 (having completed graduation) or with a SLC (School Leaving Certificate) in the S1 test form, the badminton group fared a lot better than their football counterparts as the mean scores of the badminton players was 7.00 while the mean scores of the footballers were 5.34. It might be due to fact that the S1 test form tested the hand-eye coordination which obviously the badminton players need to put in use, if they were to succeed in their sport but footballers require more eye-foot coordination, hence they would lag with regards to the tested facet.

DISCUSSION

The sensorimotor system encompasses the sensory, motor, and central integration and processing components involved in maintaining functional coordination. Further testing with regard to the eye-hand-foot coordination should be done with the same bunch of players to have an idea of the overall coordination.

Time movement anticipation deals with the individual’s ability to imagine the effect of a movement and correctly estimate the movement of objects in space. In the sub-factor of mean deviation time medium fast, there were significant differences found. Both the sports of football and badminton deal with the complex decision making and perceptual abilities which aid in making the timely header into the corner of the goal post or in hitting that booming forehand smash with pin-point accuracy. Although both the sports require an equal amount of perceptual abilities, the imagination of the movement and the estimation of objects was found better in case of football players in comparison to badminton players; while they dealt with objects hurled at them in the medium-fast range. The reason, perhaps, might be that for team games, due to the great number of stimuli, perceptive skills have a cardinal significance, especially in players’ anticipation and decision making processes (Zwierko, 2008).

CONCLUSION

Further, in-depth analysis of both the sports should be done taking into account the dominant and the non-dominant limbs of the body, as well as the skilled and the novice performers into account, and how they affect the coordination and perceptual abilities of the players. Future research should aim to identify VTS tests that are relevant to each particular sport. This is a crucial gap in the literature, as VTS has the potential to provide sport psychology researchers with an alternative assessment tool to supplement current measures.
REFERENCES


This study examined and compared the sensorimotor coordination hypothesis and determination ability hypothesis as explanations for computer gamer and non-gamer sportspersons. The study was conducted on 20 randomly selected male sportspersons (10 each in gamer [minimum 8 hours per-week] and non-gamer [who never play any kind of computer game]) in the age group 18-25 years with a mean & SD of 20.95 ± 2.19. For measuring sensorimotor coordination and determination, Vienna test system (VTS), a computerized psychological assessment tool was used. Independent ‘t’ test was applied at 0.05 level of significance and its various assumptions of normality (Shapiro-Wilk test), outliers (box plots) and homogeneity of variances (Levene’s test for homogeneity of variances) were tested. The results revealed that there is statistically significant difference in the mean of sensorimotor coordination score (8.90, p = .00) and determination test incorrect score (3.64, p = .00) between gamers and non-gamers at 18df. These results suggest that the sportspersons who play computer games have better sensorimotor coordination and determination ability when tested in VTS. Future research should combine sport performance and these methods to gain a more complete understanding of this phenomenon.

**KEYWORDS:** sensorimotor coordination, determination test, VTS
INTRODUCTION

Video games have been a popular pastime across the world since the 1970s. Their popularity has grown with the advancements in digital technology, mobile communications and the Internet in the 1990s. Gaming can be classified into PC, Console, Wireless, Multiplayer gaming and Massively Multiplayer Online Role-Playing Games (MMORPG). In India, mobile and console gaming are the most popular forms of games followed by PC gaming and MMORPG. The Indian gaming market is very small compared to other developed countries (www.icmrindia.org). Game Track estimates there are 20 million people of the 6-64 years old population gaming in the UK, or 42% (GameTrack Q2 2015). On average, the 11-64 years old Gamer population spends 8.9 hours per week on games (GameTrack Q2 2015) (Ukie.org.uk, 2015). Students aged 8-13 spend 7.5 hours per week playing computer video games (Roberts, Foehr, Rideout & Brodie, 1999), and high school students about 4 hours (Harris & Williams, 2001). In 1998, 13.3% of men entering college played such games for at least 6 hours per week (Cooperative Institutional Research Program, 1998, 1999); that figure increased to 14.8% by 1999; 91% reported that they currently played video games. Nor is this activity a predominantly male phenomenon. In a sample of 227, Anderson and Dill (2000) reported that “88% of the female college students and 97% of the male college students surveyed were video game Gamers” (p.778).

Furthermore, Roe and Mujis (1998) document that the popularity of computer games is not merely an American phenomenon. The penetration of cell phones in India was higher compared to personal computers; hence more people were likely to get their first gaming experience on a cell phone. Moreover, a large proportion of youth were keen to try out new games. The online gaming sector in India is being driven by the increasing number of Internet users, increase in disposable incomes, and propensity to spend among the youth. The growth of Internet cafes such as Sify i-way and Reliance WebWorld, who have installed online games to attract more consumers, has also contributed to the rise in online gaming. The PC gaming segment in India mainly consists of youth and college students but sportspersons, too, are becoming very obsessive in this regard. Basically, there are three “domains” of learning – cognitive, affective and psychomotor, each of which is organized as a series of levels or pre-requisites. Computer gaming can be sociable, intellectual, educational, and can improve eye-hand co-ordination, reaction times and quick thinking as a result of challenging games.

The purpose of the research was to compare the sensorimotor coordination and determination abilities of computer gamer and non-gamer sportspersons.

METHODS

A random 20 male sportspersons (10 each in gamer [minimum 8 hours per week (Ukie.org.uk, 2015) and non-gamer [who never play any kind of computer game] categories) in the age group 18-25 years with a mean & SD of 20.95 ± 2.19, having played at the national level in various sports (cricket, football, basketball), were selected. Participation of the sportspersons was completely voluntary.

The variables selected for this study were as follows:

a. Sensorimotor Coordination (SMK)
The test form used is S2. The main sub-variables for calculation are TIIR (time in ideal range) measured in percentage. It represents the percent of time the circular segment was in the ideal range.

b. Determination test
The test form used is S2. The main sub-variables for calculation are correct, incorrect and omitted. It represents the number of responses.

The subjects were tested using the Vienna Test System (VTS), a computerized test apparatus, independent samples t-test like normality (Shapiro-Wilk test), equality of variances (Levene’s test for equality of variances) and outliers (Box plots).
RESULTS
The statistical analysis of the data has been presented below. The descriptive statistics for the sample in the test taken is presented in table 1.

Table 1
Descriptive statistics of sensorimotor coordination and determination test of Computer Gamer and Non-gamer sportspersons

<table>
<thead>
<tr>
<th>Variables</th>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensorimotor Coordination (SMC)</td>
<td>Gamer</td>
<td>10</td>
<td>30.70</td>
<td>6.09</td>
<td>1.93</td>
</tr>
<tr>
<td></td>
<td>Non-gamer</td>
<td>10</td>
<td>8.70</td>
<td>4.90</td>
<td>1.55</td>
</tr>
<tr>
<td>Determination Test Correct (DTC)</td>
<td>Gamer</td>
<td>10</td>
<td>466.60</td>
<td>64.52</td>
<td>20.40</td>
</tr>
<tr>
<td></td>
<td>Non-gamer</td>
<td>10</td>
<td>446.10</td>
<td>51.15</td>
<td>16.18</td>
</tr>
<tr>
<td>Determination Test Incorrect (DTI)</td>
<td>Gamer</td>
<td>10</td>
<td>56.60</td>
<td>34.04</td>
<td>10.76</td>
</tr>
<tr>
<td></td>
<td>Non-gamer</td>
<td>10</td>
<td>105.00</td>
<td>24.59</td>
<td>7.78</td>
</tr>
<tr>
<td>Determination Test Omitted (DTO)</td>
<td>Gamer</td>
<td>10</td>
<td>29.60</td>
<td>7.52</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>Non-gamer</td>
<td>10</td>
<td>26.90</td>
<td>3.98</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Table 1 represents the mean and SD of sensorimotor score in TIIR (Time in ideal range) measured in percentage and determination test in number of responses. The table is self explanatory. The scores are illustrated graphically in figure 1. There were no outliers in the data, as assessed by inspection of the box plots in figure 2 & 3.
Table 2

Comparison of Sensorimotor Coordination and Determination Test of Gamers and Non-gamers Independent Samples Test

<table>
<thead>
<tr>
<th></th>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Sensorimotor Coordination</td>
<td>0.14</td>
<td>0.72</td>
</tr>
<tr>
<td>Determination Test Correct</td>
<td>1.22</td>
<td>0.28</td>
</tr>
<tr>
<td>Determination Test Incorrect</td>
<td>3.16</td>
<td>0.09</td>
</tr>
<tr>
<td>Determination Test Omitted</td>
<td>7.44</td>
<td>0.01</td>
</tr>
</tbody>
</table>

*significant t.05 (18df)
From Table 2 it is observed that there is statistically significant difference in the mean of sensorimotor coordination score (8.90, p = .00) and determination test incorrect score (3.64, p = .00) between gamers and non-gamers at 18 df. There was statistically insignificant difference in mean determination test of omitted score, (1.00, p = 0.33) and correct score (0.79, p = 0.44) between gamers and non-gamers at 18 df.

**DISCUSSION**
This study examined and compared the sensorimotor coordination hypothesis and determination ability hypothesis as explanations for computer gamer and non-gamer sportspersons. The results revealed that regarding sensorimotor coordination, a higher percentage of gamers stayed in the ideal range as compared to non-gamers; the determination test incorrect & omitted also revealed that the gamers were better in their responses than the non-gamers.

**CONCLUSION**
The sensorimotor coordination of the gamers was higher than the non-gamers, which ascertained that the eye-hand and hand-hand coordination of the gamers was better when coordinating one’s movements, as was essentially determined by the ability to process and recieve information. The results of a study by Boot, Kramer, Simons, Fabiani & Gratton (2008) are in consonance with this study.

The determination ability of the non-gamers was higher in the number of incorrect scores, which showed that the gamers made fewer mistakes than non-gamers. This clearly depicts that the ability of the gamers was better in handling reactive stress tolerance, and the associated reaction speed linked to it was more effective as the ability dealt with the attribute to take complex decisions under stressful, continuous, rapid and varying responses to rapidly changing stimuli.

The present research is a preliminary work to understand the difference between the sportspersons who engage themselves in computer games apart from their schedule and those who never play. Future research is required to better understand the relationship of gaming with sportspersons’ performance and its performance enhancing ability, and also as a way of enhancing their cognitive skills.

**REFERENCES**


MODELLING IN SPORTS
The aim of this study was to identify the impact of stroke lengths on the winning probability in table tennis. The performance analysis was done by mathematical simulation using a Markov chain model. 259 high-level table tennis games were evaluated by means of a new simulation approach using numerical derivation to remove the necessity to perform a second modeling step in order to determine the difficulty of tactical behaviors. Based on the derivation, the gradient is used to find differences between strokes in table tennis. Factor extraction by principal component analysis reveals four main components of performance, with long rallies as the most influencing game situations.

**KEYWORDS:** performance analysis, table tennis, simulation, markov chains.
INTRODUCTION

There has been growing interest in tactical and technical analysis in sports science (Lees, 2003). This process, also called performance analysis, aims to provide coaches the information to optimize their decision-making during competitions as well as in training. There exist several studies that aim to apply performance analysis to table tennis. Malagoli-Lanzoni, Di Michele and Merni (2011) summarize the different performance indicators commonly used in table tennis literature. Most of the studies mentioned try to assess performance by using notational analysis represented by statistics, indices and coefficients, which can be summarized as the absolute individual balance of successful and unsuccessful game actions (Lames et al., 1997). These indicators examine the individual performance outside of the context of the game actions, losing an important feature for evaluation. Hughes and Bartlett (2002) specifically emphasize that the use of match classification indicators, when observed in isolation, can be misleading.

Lames (1991) proposes a performance analysis by mathematical simulation in tennis, which is based on transition matrices and tries to support the evaluation of game situations within their respective context. By assuming specific properties of the game actions, described by the Markov chain model, transition matrices can be treated as stochastic processes which then allow the application of different computations on the matrices. The impact of a tactical behavior hereby is described by the change in winning probability induced by the changes to the transition matrices done through the simulation. Lames and McGarry (2007) use this simulative approach to determine the types of tactical behaviors relevant to athlete's performance in volleyball, while Pfeiffer, Zhang and Hohmann (2010) apply it to table tennis. In addition to the first step of modeling, where the game actions are modeled by a Markov chain, these simulative approaches need a second step to determine the relative difficulty of tactical behaviors so the changes to the transition matrices fit into the semantics of the sport. In an earlier study, we substituted this second modeling step with the application of numerical derivation (Wenninger & Lames, 2015). The aim of this study was to extend the simulation method by numerical derivation through application of the gradient, which provides the possibility to automatically detect the most impacting components of a table tennis game.

METHODS

259 matches of world class table tennis players, both male and female, were examined in this study. The evaluated games took place over the span of four years (2008-2012) in official tournaments of the ITTF, ETTU and IOC. The dataset consists of the length, server and winner per rally, together with the final result of each match. A table tennis rally was classified by the following discrete states: First to fifth stroke, more than five strokes, point and error, each for both players. Players are named “A” and “B”, with player A to be known as the winner of the match. In context of the observation system, a single rally can be seen as a system that alternates between the stroke states of the players. This system starts with the serve (first stroke) and ends with a point/error for either player A or B.

This leaves the Markov model with 36 reachable states that have to be considered in the gradient. These 36 states serve as input to the function for the winning probability, which is used to perform the numerical derivation (Wenninger & Lames, 2015). The mathematical gradient of a scalar function f is a vector operator, commonly denoted with the symbol \( \nabla \). In a cartesian coordinate system it is a vector field whose components are the partial derivatives of f. Applied to the Markov function for the winning probability the gradient results in the equation of the match. In context of the observation system, a single rally can be seen as a system that alternates between the stroke states of the players. This system starts with the serve (first stroke) and ends with a point/error for either player A or B.

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∇. In a cartesian coordinate system it is a vector field whose components are the partial derivatives of \( f \). Applied to the Markov function for the winning probability the gradient results in the equation where \( \nabla \) are the orthogonal unit vectors of the coordinate system (Kaplan, 1992).

\[
\nabla f(x_1, \ldots, x_{36}) = \frac{\partial f}{\partial x_1} e_1 + \ldots + \frac{\partial f}{\partial x_{36}} e_{36}
\]

The orientation of \( \nabla f \) is the direction in which the directional derivation of \( f \) has the largest value and |\( \nabla f \) (the length of the gradient vector) is the value of that directional derivative. When applied to the winning probability function \( f(x_1, \ldots, x_{36}) \) it results in a vector of length 36 that contains the partial derivation of each possible transition in the original matrix as its elements. The main goal of the gradient analysis is to find the strokes with an outstanding influence on the outcome of a game. Since the gradient points in the direction of “steepest” change in winning probability, it provides the possibility to automatically identify these transitions for each game and player. To that end, a game was simulated two times, one time for each player exclusively being at the serve. This also means that some transition probabilities can never be reached in a simulation. For example, if a player is serving, it can never happen that the same player hits the second or fourth ball in a rally. \( \nabla f \) therefore contains the partial derivations of all transitions that can take place in an alternating state sequence, starting with the simulated player. To obtain gradient vectors that contain only strokes of a single player, these alternations have to be taken into account. This is done by switching the corresponding derivation values between the gradient vectors. For example, to get the gradient values for the return of player A, the values from the simulation with player B as the serving player have to be considered. It also has to be taken into account that the states “point for player A” (PA) and “point for player B” (PB) have different semantics depending on which stroke is currently simulated. For example, if player A is serving, PA stands for the service aces. However if player B is the serving player, PA represents the service errors.

This separated simulation of the players also causes the gradient vector to lose dimensions. Since not all 36 states are reachable from each configuration, the vector is reduced to the size of 21. Each stroke class adds three elements to the vector: The partial derivatives of its transition probability to the next stroke and the two transitions to the absorbing point and error states. This adds up to 15 elements for the first five strokes of a player. The sixth stroke has to be split up in two classes, since it can be reached from both starting points of the simulation. This results in two subclasses for the sixth stroke: The sixth stroke after one’s own serve, and the sixth stroke after the serve of the opponent. The separation of simulation for each player sounds like a contradiction to the original goal of the Markov model, to include the interaction process between players into the performance analysis. However, the interaction between the players is not omitted, but shifted so that only a subset of the original states is considered in the simulation.

The gradients for each game were then analyzed using a factor analysis. The factor extraction was done by principal component analysis and Varimax rotation with Kaiser Normalization.

**RESULTS**

This study used the gradient to identify the most important strokes for a player in terms of absolute impact on the winning probability. As the scree plot for the factor analysis (Fig.1) shows, it appears reasonable to differentiate four main components that contribute to the variance in stroke impact, which equals to the total amount of the derivation value. However, these components are only able to explain 58.5% of the total variance, with the first component explaining 24% of the variance after rotation, the second component taking 16.8% and the last two components 9.6% and 8% respectively.
Table 2 displays the rotated factor loadings for all factors with a correlation higher than .30. The first component features a high correlation with the long stroke classes, where the rallies last 6 strokes or longer. Component three is also clearly correlated to the service, while the high correlations of component four can be attributed to the return strokes. Finally, with the exception of the factor “Point 3.”, the second component exclusively contains noticeable correlations for error and transition probabilities.

Figure 1
Scree Plot of the Factor Analysis

Table 1
Total Variance Explained

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>3</td>
<td>1.973</td>
<td>9.397</td>
<td>50.963</td>
</tr>
<tr>
<td>4</td>
<td>1.533</td>
<td>7.299</td>
<td>58.299</td>
</tr>
</tbody>
</table>
### Table 2
Rotated Component Matrix

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serve</td>
<td>.956</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point Serve</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error Serve</td>
<td>-.943</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return</td>
<td></td>
<td>.895</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point Return</td>
<td></td>
<td></td>
<td>-.873</td>
<td></td>
</tr>
<tr>
<td>Error Return</td>
<td>$.426</td>
<td>$-.326</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Stroke</td>
<td></td>
<td>$-.631</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point 3.</td>
<td></td>
<td>$.459</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error 3.</td>
<td></td>
<td>$.635</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Stroke</td>
<td></td>
<td>$.680</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point 4.</td>
<td></td>
<td></td>
<td>$-.747</td>
<td></td>
</tr>
<tr>
<td>Error 4.</td>
<td></td>
<td></td>
<td></td>
<td>$-.747</td>
</tr>
<tr>
<td>5. Stroke</td>
<td>$-.321</td>
<td>$-.510</td>
<td>$-.302</td>
<td></td>
</tr>
<tr>
<td>Point 5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error 5.</td>
<td>$.429</td>
<td>$.605</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Opp. Serve</td>
<td>$.818</td>
<td>$.366</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point 6 Opp. Serve</td>
<td>$.873</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error 6 Opp. Serve</td>
<td>$-.837</td>
<td>$-.411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Own Serve</td>
<td>$-.853</td>
<td>$-.354</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point 6 Own Serve</td>
<td>$-.890</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error 6 Own Serve</td>
<td>$.860</td>
<td>$.375</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DISCUSSION
In general, the gradient analysis includes information about the relevance of all reachable transitions of the Markov simulation. Four main components that contribute to the winning probability of a player were revealed by the factor analysis of the gradient. In compliance with the findings of our previous study, the long rallies lasting more than five strokes were identified as the most impacting class of strokes during a match. The second component almost exclusively contains transient transitions (transitions to the next stroke), as well as transitions to the error states (direct errors). Because these behaviors are contradicting in the tactical context of a table tennis game, the definition of a general term that includes both of these stroke classes is quite difficult. One way of classifying these strokes could be to formulate a reverse definition and label them as the strokes, where no direct point is made.

On the contrary, the third and fourth components are clearly related to the serve and the return strokes again.

While the gradient in combination with a factor analysis proves to be an effective method to identify key elements of performance, future work on the method could apply a cluster analyses on the gradient on a per game basis to find similar game types, players or even match-ups.
CONCLUSION
In the present study, stochastic simulation using a Markov chain model of table tennis and the gradient was used for the first time. In combination with a factor analysis, this method can be directly applied to different sports to find high-level components of performance. Finally, the application in table tennis was tested and four main components of performance with respect to the Markov model were found.

REFERENCES:
Training and competition predictions and prescriptions are always based on level tracks. Therefore, reference speeds and heart rates (HR) would help an athlete in altitude profile in order to run decline and incline optimally without overstraining and underperforming. 11 physically active participants performed five graded incremental tests with different decline and incline degrees (-2%, 0%, 2%, 4% and 6%). HR was measured continuously and a characteristic HR for each step was determined. HRs can be estimated best with a third order polynomial with a percentage value of decline and incline degree as single variable. Function parameters partly show high individual variation. Knowing the characteristic level HRs, reference HRs can be determined. Based on these, reference speed can be determined for more detailed prescriptions.

**KEYWORDS:** speed, heart rate, endurance, prescription, altitude profile, incline, decline
INTRODUCTION

Speed or heart rate (HR) prescription in endurance running competitions can be determined in different ways. One can use empirical formulae based on different anthropometric data (Tanda & Knechtle, 2015), exhaustive test runs (Till et al., 2016) or simulations based on computer science models, such as the Performance Potential metamodel (PerPot) adapted to running (Endler, 2013). However, all these predictions do not include the altitude profile of the competition. However, in a real-life setting, nearly every competition includes altitude. In these cases, it is dangerous to run a constant pace ignoring particularly incline. Keeping a constant speed during an incline would deduce an increasing HR. An athlete may temporarily use a different provision of energy followed by a delayed premature collapse.

Snyder & Farley (2011) found no energetically differences at different stride frequencies by means of varying incline and decline. Overall, incline running was poorly considered for training purpose until now (Ferley & Vukovich, 2015). Merely the study of Padulo et al. (2013) examined HR besides other metabolic parameters on different incline degrees (2% and 7%). However, no individual effects were considered and it was not a goal of this investigation to find a function for further use in training or competition prescription. Furthermore, decline was not considered.

Therefore, this investigation examines speed and HR running at different incline and decline degrees. A function should be found for determining reference speeds and HRs, which can be used for a more detailed prescription of endurance running competitions.

METHODS

19 (13 males, 6 females) teachers and students of the Hessian police participated the investigation. 11 (7 males, 4 females) participants aged between 20 and 59 completed the whole investigation and were included to further analysis. All participants were physically active (4-10 hours per week), which is a prerequisite for police officers. Participants performed five graded incremental tests under different decline and incline degrees (-2%, 0%, 2%, 4% and 6%) on a treadmill with HR monitoring.

The treadmill Excite® Run-Now 700+ by TechnoGym was applied in an air-conditioned hall at the police school location in Mühlheim. Speed can be adjusted in 0.1 km/h steps up to 27 km/h. Incline degrees can be adjusted in 0.5% steps from 0% up to 14%. Due to safety concerns no treadmills where decline can be adjusted are available at the moment on the market. Thus, we produced a customized multiplex board to produce a decline of -2%.

Polar® heart rate monitors by Polar® Electro Oy consisted of electrode belt, transmitter WearLink® W.I.N.D. and heart rate monitor RS800CX were used for this purpose. Data is transmitted to a computer via an infrared interface and can be visualized and edited using the Polar ProTrainer 5TM software. After transmission, the data is available as .hrm file for further determination. HR was recorded in five second intervals.

All graded incremental tests started with an initial speed of 6 km/h for three minutes and incremental 1.5 km/h increases every three minutes until subjective exhaustion was reached. Subsequent to the last incriminatory step, another step of three minutes with the previous initial speed of 6 km/h took place.

The five graded incremental tests with different decline and incline degrees were executed in personally randomized order in order to minimize habituation effects, which could occur in a linear increasing test order. After every test, participants had at least two and at most four days of rest. Most participants waived further training during the test period.

For further data analysis characteristic HRs were determined for each step of all graded incremental tests. We defined this characteristic HR as mean HR between 1:15 min. and 2:50 min. of every three minute step. Since the delayed HR adaptation to a new speed, the first 75 seconds of each step were not used for determination. The last 10 seconds of each step were not used, because of a mental effect. If an athlete knows,
that the next step starts in a few seconds, in some cases HR increases before the new speed level starts.

Based on these HRs, percental differences were determined:

1. The differences within each graded incremental test between two sequent steps

2. The differences between HRs measured during a test with decline and incline compared to level HRs at the same speed level.

First of all, these differences were used to examine the influencing factors on HR, speed and decline/incline degree, respectively. Now, findings can be used for searching a function which determines factors for reference HRs. Later on these reference HRs can be used for determining reference speeds.

The optimal function for each participant’s data was searched using the Excel 2016 Solver. Minimization criterion was the route mean squared error (RMSE), comparing the factor determined by measured data and the factor determined by a function. The solver used the generalized reduced gradient nonlinear algorithm for optimization of function parameters.

RESULTS

First of all, percental differences of the HR show no differences between each graded incremental test, as shown in Table 1 exemplary for one participant. Converting these percental values to real HRs, standard deviation of the difference between two sequent steps is two beats per minute at most. That is speed has no more or less influence to a graded incremental test with or without decline/incline, respectively.

### Table 1

Percentages of heart rate increase from one step to the next. Exemplary for participant 4.

<table>
<thead>
<tr>
<th>Speed increase</th>
<th>-2%</th>
<th>0%</th>
<th>2%</th>
<th>4%</th>
<th>6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 7.5</td>
<td>2.91</td>
<td>4.49</td>
<td>5.28</td>
<td>6.08</td>
<td>10.16</td>
</tr>
<tr>
<td>7.5 to 9</td>
<td>6.23</td>
<td>5.74</td>
<td>7.14</td>
<td>9.03</td>
<td>10.16</td>
</tr>
<tr>
<td>9 to 10.5</td>
<td>8.64</td>
<td>7.57</td>
<td>8.45</td>
<td>9.38</td>
<td>7.71</td>
</tr>
<tr>
<td>10.5 to 12</td>
<td>8.27</td>
<td>8.19</td>
<td>6.80</td>
<td>7.62</td>
<td>6.63</td>
</tr>
<tr>
<td>12 to 13.5</td>
<td>9.61</td>
<td>7.05</td>
<td>5.96</td>
<td>6.55</td>
<td></td>
</tr>
<tr>
<td>13.5 to 15</td>
<td>6.94</td>
<td>6.14</td>
<td>5.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 to 16.5</td>
<td>7.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>7.13</td>
<td>6.53</td>
<td>6.52</td>
<td>7.73</td>
<td>8.67</td>
</tr>
<tr>
<td>sd</td>
<td>2.18</td>
<td>1.35</td>
<td>1.19</td>
<td>1.46</td>
<td>1.78</td>
</tr>
</tbody>
</table>

Hence, speed is no major influencing factor and must not be integrated into the function. In contrast, incline shows a high influence on HR at the same speed level, as shown in Table 2 exemplary for the same participant as Table 1.
For each individual case an optimal function was searched with decline/incline degree in percent as single variable. In all cases, the third order polynomial shows the lowest RMSE’s ($0.083\pm0.033$):

$$f(x) = ax^3 + bx^2 + cx + 1$$

However, parameters $a$, $b$ and $c$ show individual high differences in some cases, leading to varying curve progression as presented in Figure 1.

### Table 2
Percentages of heart rate increase compared to 0%. Exemplary for participant 4.

<table>
<thead>
<tr>
<th>Speed</th>
<th>-2%</th>
<th>2%</th>
<th>4%</th>
<th>6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>-8.35</td>
<td>4.29</td>
<td>6.26</td>
<td>11.44</td>
</tr>
<tr>
<td>7.5</td>
<td>-9.74</td>
<td>5.08</td>
<td>7.87</td>
<td>17.49</td>
</tr>
<tr>
<td>9</td>
<td>-9.32</td>
<td>6.47</td>
<td>11.23</td>
<td>22.40</td>
</tr>
<tr>
<td>10.5</td>
<td>-8.42</td>
<td>7.34</td>
<td>13.09</td>
<td>22.56</td>
</tr>
<tr>
<td>12</td>
<td>-8.36</td>
<td>5.95</td>
<td>12.49</td>
<td>20.79</td>
</tr>
<tr>
<td>13.5</td>
<td>-6.17</td>
<td>4.88</td>
<td>11.97</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>-5.46</td>
<td>4.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For each individual case an optimal function was searched with decline/incline degree in percent as single variable. In all cases, the third order polynomial shows the lowest RMSE’s ($0.083\pm0.033$):

$$f(x) = ax^3 + bx^2 + cx + 1$$

However, parameters $a$, $b$ and $c$ show individual high differences in some cases, leading to varying curve progression as presented in Figure 1.

![Figure 1](image-url)

**Figure 1**

Function shapes for every individual case (green lines) and the mean (blue line).
This function can be used for a detailed prescription of speed. Figure 2 shows the usage in PerPot. Knowing some characteristic HR values from level runs, i.e. graded incremental tests or training runs, HR values in between can be determined by means of linear interpolation. Using the function, a table including all HRs at different decline and incline degree based on the level HRs can be build. If the altitude profile is known, reference speed values can be determined by looking at the speed value corresponding to the HR optimized by PerPot at the specific decline/incline.

**DISCUSSION**

Reference speed for altitude profile can be determined by means of a third order polynomial. However, function parameters should be optimized for every athlete individually due to high variation. For practical purpose, the procedure presented in this investigation is too complex. One solution could be the use of training data in the field to generate enough data for a parameter optimization. However, this is not standardized and should only be accepted with caution. Anyway, using the function with mean parameters is better than neither using any altitude optimization.

Using our function with mean parameters, findings of Padulo et al. (2013) could be verified. Differences between stated HRs and determined HRs are 3.05±2.79. For one measurement, our function produces a more feasible value, because the measured HR at 2% incline is lower than the corresponding level HR.

A disadvantage of our investigation is missing examination of high decline degrees. Using the third order polynomial for determination of reference HRs in high decline would produce faulty HRs, because function factors decreases with growing decline and even get negative. In contrast Perl & Endler (2006) stated an increasing HR running at high decline. This might be due to higher load on the knee, amongst others. Hence, a fourth order polynomial might be a better function to work for high decline too.

**Figure 2**

PerPot simulation of optimal speed (blue) and heart rate (green) using an altitude profile.
CONCLUSION
Reference HR and speed for altitude profile can be determined by use of a third order polynomial with decline and incline degree as single variable. Parameters of the function should be optimized individually. But even the use of mean function parameters can help athletes to prescribe training and competition runs in more detail.

REFERENCES:


The main goal of this paper is to present an innovating online system, built through free software and statistics tools that allow a comparison of individuals in any sport modality. Particularly, this shown study is focused in the performance evaluation in soccer, using univariate and multivariate statistical methods. The univariate approach is given by the Z-CELAFICS methodology and the multivariate is given through a novel construction of indicators using Principal Component Analysis, Factor Analysis and Copulas. The created system shows many dynamic online reports that allow us to observe the results of the subjects in the tests and who is more suitable for the practice of this sport.

**KEYWORDS:** sport evaluation, z-celafiscs methodology, principal component analysis, factor analysis, copula theory.
INTRODUCTION

Nowadays soccer is the most practiced sport in the world, with about 265 million players (men and women). If we include umpire e officials, we have about 270 million people actively involved, which represent 4% of the world’s population (Kunz [2007]). Besides evolving this large number of people, soccer moves a multi-millionaire market (Elferink-Gemser et al. [2012]) and the economic benefits of a team being able to recruit talented players and develop them to their fullest potential are obvious (Reilly et al. [2000]). For example, if we observe the three most valuable casts currently: Real Madrid, FC Barcelona and Bayern Munich, we have a value of each cast of €688,80, €620,00 and €568,15 million, respectively (Markt [2014]).

Accordingly with Reilly et al. [2000], to identify talents for field games at a young age is far from being a mechanistic process, being more complex in group sports than in individuals.

Therefore, it is not surprising that there are few, if any, models to identify talents that are globally accepted. According to the authors, many of the proposed models are, in the best case, descriptive and schematic and there are few attempts to identify its validity.

At our best knowledge, there are not studies in the literature that work systematically procedures of specific tests, beginning with data collection, theoretical development, application and developing a software that allows an integrated structure focused on the selection and development of talents specifically on soccer. It leads us to an innovating structure in applied statistics on sports that possibly will be common in the near future, including in other areas of knowledge. Across that requirement the iSports (Louzada et al. [2016]) system was born.

METHODS

To select the evaluation performance tests to be used on the system, a collection of tests applied to the evaluation of soccer player was displayed to an expert and a trainer of the sport, so that they could select the physical e technical tests to be used. The technical abilities tests selected were: Mor and Christian pass test, 5 cones dribbling test and a kick after pass test. The physical tests were: 1000 meters on a track test, cyclic speed of 20 meters test and the anaerobic power test (RAST). The statistical analyses are Z Method [Matsudo et al., 1987], Principal Component Analysis and Factor Analysis [Johnson and Wichern, 2007], Copula Theory [Nelsen, 1999].

RESULTS

The iSports provides the data gathering of some specific sport tests and several ways to analyze these data using powerful statistical methodologies directed to talent detection. Some parts i-Sport system are presented in Figure 1-3.
**Figure 2**

Player with the highest overall score and greater consistency.
**DISCUSSION**

Available reports show the global and individual information of athletes, and it is possible to evaluate the classes separately or make a general assessment considering all individuals. Following is a description of each available test:

- **Overview of students**: presents an overview of the basic characteristics of the individuals, such as age, height and weight;
- **Overall performance of the tests**: presents information of the income of the individuals, in a global way, in all 6 tests applied;
- **Best players physically**: displays the information of individuals that were best physically. Initially, the report displays the top 5, but there is the possibility of displaying the ranking of all registered students in iSports;
- **Players with greater technical skill**: displays the information of individuals that were best technically. As in the report for the best players physically, this report allows you to view both the 5 best technically as the ranking of all individuals;
- **Players with better ratings**: Displays the information of individuals that were best globally, that is, players with higher fitness to soccer field. You can either display the top 5 as the ranking of all individuals registered in iSports;
- **Most consistent players**: displays the information of the most consistent individuals, that is, the most complete players considering the tests...
applied. Again it is possible to see the top 5 and the ranking of all registered students in the system;

• Individual performance: exposes an individual report for each person, which will display all the statistical analysis of the performance of the individual;

• Compare classes: compares the class’s indicators and displays some descriptive measures of the tests applied on each class.

CONCLUSION

In this paper we presented the iSports system, available at http://www.mwstat.com/isports, to the soccer field module as an online statistical tool directed to the detection of sporting talents. The iSports allows the monitoring and the continuous comparison of athletes in a simple and efficient way, taking into account the necessary technical and physical aspects, as well as identify talented athletes that have better technical and physical aspects, “above the average”, that is, players who are detached statistically from the population of soccer players. In order to promote and publicize the access of information and the statistical science applied in the sports context, the iSports system can be used in any training center of the country, impacting in the greater knowledge of the athletes in training phase at any school, city or region. Since the whole system is made into a “cloud”, there is no need for installation of software in the places the system will be used and just a connection with Internet is enough for the iSports may be used. Through this instrument, an athlete in any training center of its respective sport can compare their results with the other athletes in the local, regional and national matter. Training centers may also be compared with all other centers in regional and state level. Similarly, the various regions of the country (states and regions geographically) can be compared in order to quantify their contribution in training athletes. In this context of multiple comparisons, as pointed out in the comparison chart among the scores of other students shown in Figure 2, students will not have access to the other’s identity, or even the identity of the training centers will be revealed, which ensure no exposure of the property and also the privacy of the athletes.

For the future prospects, we have the development of new targeted modules the other sports, besides the continual improvement of the presented module and directed to the field of soccer. Thus, we visualize the iSports system being used nationally for detection sporting talents, giving equal opportunities to athletes of all categories that would find difficulties to be discovered since they cannot be easily detected with the methodology currently employed.

REFERENCES


The purpose of this study is to examine the relationship between Relative Age Effect (RAE) and maturity level applied for selection. Augste and Lames (2011) gave the interpretation of a RAE as indicator of selecting according to momentary performance that in turn is determined by maturity level in youth samples. It has been shown that with a small set of assumptions one is able to model the relationship between birthday distribution and biological age applied as selection threshold (Lames & Werninger, 2012). Effect size of a RAE may be described by the median of the birthdays of the sample examined (Augste & Lames, 2011). This study models the functional relationship between the median of birthdays and the maturity level applied for selection.

**KEYWORDS:** Modeling, RAE, Skeletal Maturity.
INTRODUCTION

The Relative Age Effect (RAE) in sports has recently been investigated in many studies (see Musch & Grondin, 2001 for a review). RAE designates a bias of the birth dates in a sample of athletes preferring in general those that are born early in the selection period. Research has shown that a RAE just stands for preferring early mature athletes in a selection at young age (Diamond, 1983; Baxter-Jones, 1995).

Extended research has been devoted to clarify the relationship between RAE and maturation (Hirose, 2009; Sherar, Baxter-Jones, Faulkner & Russell, 2007; Baxter-Jones, 1995; Vincent & Glamser, 2006). Augste and Lames (2011) take the existence of a RAE as sign for selection according to the momentary strongest athletes, which are typically the more mature ones. In this respect a RAE is just a code for selecting early maturers. Also, they introduced a statistically founded measure for the effect size of a RAE, the median of the birthdays. In a conference paper from 2012 Lames and Werninger demonstrated that the distribution of birthdays allows the reconstruction of the maturity level for selection most likely associated with that distribution. This study extends this method to the calculation of the relationship between median of birth days in a sample to skeletal age threshold most likely applied in selection.

METHODS

The problem was addressed by building a model for the selection process based on mathematical assumptions. Biological age may be assumed to be normally distributed with chronological age as mean value and a standard deviation spop that is typical for the population the sample is drawn from (Sherar et al., 2007). An athlete with a biological age one year ahead of his chronological age would have a value of biological age x=-1.

As the sample is selected from a population of athletes born at the k-th of n time intervals (n=365 days/12 months/4 quarters) the probability of being in age class k and meeting the biological requirements is:

$$P(k) = \frac{\int_{-\infty}^{x} N(k_{\text{pop}}, s_{\text{pop}})}{n \cdot \int_{-\infty}^{x} N(k_{\text{pop}}, s_{\text{pop}})}$$

If one calculates this probability for each k one gets the expected distribution of birthdays applying a biological age of x as selection threshold. From this distribution, one calculates the median as effect size of the RAE. Augste and Lames (2011) classified a median before 1st of March as a “very strong” RAE, a median in March as “strong”, a median in April as “medium”, in May as “weak” and after this as “neglible”. Now it is possible to calculate iteratively a selection threshold value x for any median of birthdays.
RESULTS
Figure 1 shows the expected distributions of birthdays over the year dependent on the effect size for RAE. It may be noted that even for a negligible RAE (median 1.6.), there is a bias towards a higher proportion of players born in the first half of the year. This proportion rises dramatically though, when effect size gets stronger.

Figure 1
Expected distribution of birthdays for some selected effect sizes of RAE.

Figure 2 shows the biological selection thresholds relative to chronological age in years (negative: selection threshold lower than chronological age of population; positive: biological age for selection ahead of chronological age of population) and the corresponding median of birthdays in a squad.

The first interesting feature of this graph is the intersection of selection level equals chronological age (0 years) with a median of 13th of May, indicating a weak RAE. This is surprising at the first glance, because one wouldn’t expect a substantial RAE with chronological age as selection threshold. On the other hand, if selection is made at an average level of maturity, players born early in the year have a greater probability to meet this demand, therefore a greater probability to be selected, and therefore this gives rise to a still substantial RAE.

We see then an asymptotical behaviour of the curve towards very advanced biological age as selection thresholds. Since there is a limiting floor effect for the RAE, the median may not get smaller than 1st of January, increasing the biological threshold makes the RAE approximate asymptotically this limit. Of course, one has to admit that at this margin the model becomes academic, because being ahead of as much as 4 years for example is an extremely rare case. This corresponds to empirical findings revealing most extreme RAEs only down to a median of about February, 15th, with only a few exceptions found so far.
In the other direction, we find asymptotical behaviour of the model as well. Applying a very low biological threshold, even lower or much lower than the chronological age of the population will asymptotically result in a uniform distribution of chance to be selected, no matter whether a player is born late or early in the year. This interesting finding may be interpreted in a way that lowering the biological threshold finally results in abandoning any selection effect based on physical development, thus giving each player the same chance to be selected.

**DISCUSSION**

The presented model describes the impact of applying a threshold of biological maturity in talent selection on the RAE of the selected talents. It makes the assumption that biological age is normally distributed with chronological age as mean and a standard deviation typically for the population the talents are drawn from. With these few and plausible assumptions it is possible to calculate for each individual in the selection year the probability of meeting a certain selection threshold expressed in biological age relative (mostly ahead of) chronological age. This may be done for each age class $k$ out of $n$ age classes ($n=4$ quarters, 12 months, 365 days) resulting in an expected birthday distribution for a sample selected with a specific threshold. Lames and Werninger (2012) have demonstrated that using a least square estimation one is able to calculate the most likely biological threshold that was applied when selecting the squad using its empirical birthday distribution. In this paper it is shown how an ideal birthday distribution may be obtained from a given median of birthdays. This median was introduced by Augste and Lames (2011) as a measure for the effect size of a RAE. Finally, one may establish the functional relationship between median of birthdays and biological selection level applied giving inside into the nature of this relationship. A discussion of the limitations of this study must mention that here a selection process is simulated that is based entirely on biological age as selection criterion. In practice, this is hardly the case. The model assumes biological age as normally distributed which is in accordance to prevailing knowledge (Sherar et al., 2007; Medic, Starkes, Weir, Young, Grove, 2009). Moreover, the method is dependent on a valid estimate of $s!$, the standard deviation of biological age in the population the sample is drawn from.
from. The value of $s_{\text{pop}} = 1$ underlying the results in this paper is taken from the results of several studies (Cumming, Garand & Borysyk, 1972; Lintunen, Rahkila, Silvennoinen & Oesterback, 1988; Sharma, 1993). Finally, one must admit that a mathematical model, especially with asymptotic behavior applies only partially to reality. It holds only for a realistic interval of birthdays for example.

**CONCLUSION**

Modelling complex processes is a rewarding research method given the appropriateness of its application. It allows new insights in the modelled processes as is demonstrated in this paper that reveals two asymptotic properties in the relationship between RAE and biological selection threshold. The model helps in understanding real life talent selection processes.

**REFERENCES**


The objective of the study was to explore the influence of different training modes on the motor abilities and skill related performance components of footballers. 60 male footballers aged 18 to 25 years were allocated to; Group ‘A’ Continuous running Group ‘B’ fartlek training, Group ‘C’ Interval training and Group ‘D’ control group. All groups trained 3 days per week for 8 weeks for 50 minutes a session. A pre and post-test was obtained on the muscular endurance, flexibility, pulse rate, kicking for distance and dribbling. The results of muscular endurance, flexibility and pulse rate revealed that CRG. FTG and ITG had significantly improved after the training in all the motor components compared with the control group but there were insignificant changes in kicking for distance and dribbling.

**KEYWORDS:** Fartlek training, continuous running, interval training, muscular endurance, flexibility.
INTRODUCTION

Delineation of training is to execute any physical exercise in a systemic mode. To increase the overall performance in physical aspect and skill, athletes indulge in specific training with the sole resolve of winning. The base of training revolves around running, jumping and throwing which embraces the whole continuum of human movement (Gambetta, 2002). Training advances the role of the circulatory, respiratory and muscular system, while on the other hand practice is essentially intended at refining, the control of muscular activity by the nervous system. Diverse training approaches have been universally used to develop physical fitness and its allied standards of performance of the performers (Brown et al., 2000). Each category of training yields its own outcomes on fitness and the paramount training regimen escalates the preferred value at an advanced degree without triggering undesirable effects (Bompa, 1999). Fitness is considered as a condition which illustrates the mark to which the person is capable to function. It denotes the aptitude of each individual to live most meritoriously with his potential of physical, mental, emotional, social and spiritual components fully developed (Ibrahim & Kumar, 2011). Motor ability is a broad attribute or ability of an individual comparatively persistent characteristic and aids as a determining factor of a person’s accomplishment prospective for the enactment of precise techniques. It can also be defined as the ability precisely associated to the performance of a motor skill and each individual has a range of motor aptitudes. A motor proficiency is a task, which encompasses the specific effort of muscles with the resolve to execute a definite act. Most resolute activity necessitates the aptitude to “feel” or sense what one’s muscles are performing as they execute the act (Wang et al. 2006). Keeping above factors in back of the mind the researchers have tried to observe how the different modes of training affect the motor abilities and skill related performance variables on footballers.

METHODS

Sixty male footballers between 18 to 25 years were the subjects divided into 4 equal groups, Group ‘A’ undertook Continuous running (CRG), Group ‘B’ trained fartlek (FTG) Group ‘C’ undertook Interval training (ITG) and Group ‘D’ acted as control group (CG). All groups trained three days a week for 8 weeks for 50 minutes per period. The data were obtained before the exercise periods (pre-test) and after the 8 weeks of the exercise period (post-test). The motor variables were Muscular endurance & Flexibility whereas the physiological element was pulse rate with the skill components of kicking for distance and dribbling. ANCOVA was utilized to find significant changes between all the groups in the selected components, the Scheffe’s post hoc test was utilized whenever the adjusted post-test means were found significant. The data were analyzed using SPSS statistical packages with significance level at 0.05.

RESULTS

The results of the study were analyzed and presented in the tables: Table 1 displaying the Analysis of Covariance for the Muscular Endurance, Flexibility, Pulse rate, Kicking for distance and Dribbling for all the four groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test</th>
<th>CRG Mean±SD</th>
<th>FT Mean±SD</th>
<th>ITG Mean±SD</th>
<th>CG Mean±SD</th>
<th>'F' ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscular Endurance</td>
<td>Pre</td>
<td>24.00±2.09</td>
<td>25.26±1.57</td>
<td>25.066±1.48</td>
<td>25.066±1.48</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>33.46±2.47</td>
<td>34.46±1.96</td>
<td>34.20±1.74</td>
<td>24.26±1.86</td>
<td>86.88***</td>
</tr>
<tr>
<td></td>
<td>Adj. Post-test M</td>
<td>34.07</td>
<td>34.11</td>
<td>34.07</td>
<td>24.13</td>
<td>43.10**</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Pre</td>
<td>20.00±2.33</td>
<td>20.3±2.49</td>
<td>20.27±3.03</td>
<td>20.27±2.76</td>
<td>0.046</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>24.07±2.43</td>
<td>24.07±2.23</td>
<td>24.67±3.03</td>
<td>19.47±2.61</td>
<td>13.94***</td>
</tr>
<tr>
<td></td>
<td>Adj. Post-test M</td>
<td>24.26</td>
<td>24.49</td>
<td>24.82</td>
<td>19.42</td>
<td>140.12****</td>
</tr>
</tbody>
</table>
The table 1 displays that the pre-test ‘F’ value of 0.76 on muscular endurance was not significant (P < 0.05). The post-test mean values for (CRG), (FTG), (ITG) and (CG) were 33.46, 34.46, 34.20 and 24.26 respectively. The resultant ‘F’ value of 86.88 for post-test scores on muscular endurance was significant (P > 0.05). The adjusted post-test mean values on muscular endurance for (CRG), (FTG), (ITG) and (CG) were 34.07, 34.11, 34.07 and 24.13 respectively. The achieved ‘F’ value of 43.10 for adjusted post test scores on muscular endurance was significant (P > 0.05). Scheffe’s post hoc test revealed a noteworthy change among the all the experimental groups and the control group but there was no substantial variation among all the experimental groups.

With regard to the pre-test on flexibility there no substantial difference (P < 0.05). The mean values for post-test of (CRG), (FTG), (ITG) and (CG) were 24.07±2.43, 24.07±2.23, 24.67±3.03 and 19.47±2.61 respectively. The gained ‘F’ value of 13.94 for post-test values on flexibility was significant (P > 0.05). The adjusted post-test mean scores on flexibility for (CRG), (FTG), (ITG) and (CG) were 24.26, 24.49, 24.62 and 19.42 respectively. The achieved ‘F’ value of 43.10 for adjusted post test scores on muscular endurance was significant (P > 0.05). Scheffe’s post hoc test revealed a noteworthy change among the all the experimental groups and the control group but there was no substantial variation among all the experimental groups.

The results of the pre-test on pulse rate were not noteworthy (P < 0.05). The mean values for post-test of (CRG), (FTG), (ITG) and (CG) were 66.93±0.884, 67.13±0.915, 67.13±0.834 and 73.00±0.845 respectively. The gained ‘F’ value of 174.530 for post-test values on pulse rate was significant (P > 0.05). The adjusted post-test mean scores on pulse rate for (CRG), (FTG), (ITG) and (CG) were 24.26, 24.49, 24.62 and 19.42 respectively. The elucidated ‘F’ value of 140.12 for adjusted post-test values on pulse rate was significant (P > 0.05). Scheffe’s post hoc test revealed significant differences between the all the experimental groups and the control group but no significant difference was observed among all the experimental groups.

The table also showed that the pre-test ‘F’ value of 0.692 for Kicking for distance was not significance (P > 0.05). The mean values on post-test for kicking for distance for (CRG), (FTG), (ITG) and (CG) were 48.67±3.867, 50.00±3.873, 50.00±3.566 and 47.53±3.440 respectively. The obtained ‘F’ value for kicking for distance was found insignificant (P > 0.05) in the post-tests. The adjusted mean values for post-test on kicking for distance of (CRG), (FTG), (ITG) and (CG) were 49.77, 49.86, 49.74 and 48.80 respectively. The identified ‘F’ value for adjusted post-test scores of 109.53 on kicking for distance was significant (P < 0.05). Scheffe’s post hoc test for the kicking for distance was found significant difference between all the experimental groups when equated with the control group, but there was no change amongst the experimental groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test</th>
<th>CRG Mean±SD</th>
<th>FTG Mean±SD</th>
<th>ITG Mean±SD</th>
<th>CG Mean±SD</th>
<th>‘F’ ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulse rate</strong></td>
<td>Pre</td>
<td>71.73±1.100</td>
<td>72.07±1.033</td>
<td>71.73±1.163</td>
<td>71.53±0.915</td>
<td>0.657</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>66.93±0.884</td>
<td>67.13±0.915</td>
<td>67.13±0.834</td>
<td>73.00±0.845</td>
<td>174.53*</td>
</tr>
<tr>
<td></td>
<td>Adj. Post-test M</td>
<td>66.95</td>
<td>66.98</td>
<td>67.15</td>
<td>73.11</td>
<td>279.55*</td>
</tr>
<tr>
<td><strong>Kicking for Distance</strong></td>
<td>Pre</td>
<td>46.47±4.340</td>
<td>47.87±4.357</td>
<td>48.00±4.071</td>
<td>48.53±3.602</td>
<td>0.692</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>48.67±3.867</td>
<td>50.00±3.873</td>
<td>50.00±3.566</td>
<td>47.53±3.440</td>
<td>1.56</td>
</tr>
<tr>
<td></td>
<td>Adj. Post-test M</td>
<td>49.77</td>
<td>49.86</td>
<td>49.74</td>
<td>48.80</td>
<td>109.53*</td>
</tr>
<tr>
<td><strong>Dribbling</strong></td>
<td>Pre</td>
<td>17.90±1.345</td>
<td>17.83±1.316</td>
<td>17.67±1.196</td>
<td>17.67±1.190</td>
<td>0.136</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>17.30±1.254</td>
<td>17.30±1.306</td>
<td>17.11±1.172</td>
<td>17.71±1.196</td>
<td>0.592</td>
</tr>
<tr>
<td></td>
<td>Adj. Post-test M</td>
<td>17.17</td>
<td>17.24</td>
<td>17.21</td>
<td>17.81</td>
<td>86.02*</td>
</tr>
</tbody>
</table>
It was indicated in the above table that the pre-test 'F' value for dribbling was not significance (P > 0.05). The mean values for post-test on dribbling of (CRG), (FTG), (ITG) and (CG) were 17.30±1.254, 17.30±1.306, 17.11±1.172 and 17.71±1.196 respectively. The obtained 'F' value of 0.592 with regard to dribbling was found insignificant (P > 0.05) in the post-tests. The adjusted post-test mean values on dribbling for (CRG), (FTG), (ITG) and (CG) were 49.77, 49.86 49.74 and 46.80 respectively. The gained 'F' value for adjusted post-test scores of 109.53 on dribbling was significant (P < 0.05). Scheffe's post hoc test observed significant difference between all the experimental groups when equated with the control group, but there was no change between the experimental groups.

**DISCUSSION**

The key aim of the investigation was to find how the different modes of training affect the motor abilities and skill related performance variables on footballers. The finding of the study on muscular endurance reveals that the experimental groups namely Continuous, Fartlek and Interval training has significantly improved muscular endurance after the training. The above conclusion and remarks made by Wang et al., (2006) and Xu Dq et al., (2006) piloted and determined that continuous and interval training methods were equally effective in developing endurance and hence are in agreement with our study. The outcomes of the study on flexibility was in agreement with the following studies namely Fatourous (2002) found that aerobic training strength training and combination significantly increased range of motion. Segal (2004) revealed that Pilates training improved flexibility. Srivastava (2013) suggested that Pilates exercise and callisthenic exercise increased flexibility. With regard to the resting pulse rate our study showed that the training period of twelve week of continuous fartlek and interval training reduced the resting pulse rate of the experimental group when equated with control group. The finding of the study are in conformity with the result of Astorino and Allen (2012)Short term high intensity interval training reveals that resting heart rate significantly reduced. Manna et al., (2006) found that training induced substantial decrease in heart rates during rest, sub maximal exercise, maximal exercise and retrieval. The skill performance of the subjects of the study revealed that the outcome of continuous running Fartlek and interval training significantly improved the kicking for distance performance. Rubley et al., (2011) founded that kicking for distance is significantly improved due to impact of sports training programme. Nazrul Islam Mallick et al., (2013) found that the effect of harness running, sand running, weight-Jacket running and weight training significantly improved the kicking performance between the soccer players and founded that after six weeks of training kicking speed increased when compared with control group. Hence these studies are in conformity with our study. The result of continuous, fartlek and Interval training significantly improved the dribbling when compared with control group. The results of the study are in agreement with the following studies. Haghiri (2012) suggested that plyometric and resistance training significantly improved skill performance. Bupesh (2011) found that training protocol significantly improved dribbling after the training period. Nazrul Islam Mallick et al., (2013) showed at varied types of running significantly improved the dribbling skill of the soccer player. Hence all the above studies have reported improvements in the variables of the study when the experimental groups were compared with the control. The only hitch was that no noteworth changes were detected among all the experimental groups in all the variables of the study which may be due to many factors.

**CONCLUSION**

It was concluded that three the experimental groups improved in their performance in the all the motor related components under study when compared with the control group but there was no significant affect among the experimental groups. Further there was no change in the skill related components of the study.
REFERENCES


The purpose of this study was to analyze technical and tactical characteristics of successful and unsuccessful teams in U-20 Women’s World Cup 2014. We analyzed all the 32 games that happened in the tournament. For each team we collected total shots, shots on goal, fouls, corner kicks and ball possession per game. We found that winning teams showed greater ratios of goals scored, total shots and shots on goal per match than the losing teams. Winning teams also had greater ball possession. Semi-finalists teams presented higher ratios of goals scored, total shots, shots on goal and corner kicks per match than the non-semi-finalists teams. Our results suggest that successful women’s soccer teams have greater offensive strategies which allow them to create more opportunity to shoot, to shoot on goal and, consequently, to score more goals. This information is valuable for coaches to plan more efficient training programs.

**KEYWORDS:** performance analysis, game-related statistics, female football.
INTRODUCTION
The analysis of performance indicators relating to match outcome is useful from a strategic and tactical perspective in team sport (Roberson, Back & Barlett, 2015). Such analysis can provide valuable information to coaches about aspects that should be prioritized in training and to identify strengths and weaknesses of an opposition team (Castellano, Casamichana, & Lago, 2012). The use of an appropriate tactical strategy can improve chances of winning a game, being an aspect of great importance in soccer.

In recent years the popularity of women’s soccer has increased markedly, as well as the number of studies focused on the sport (Datson et al, 2014). Despite the importance of technical and tactical aspects for game outcome, most of the studies about women’s soccer have focused on the sociological and physiological aspects of the sport.

The few published studies in this area analyzed technical and tactical elements performed by winning and losing women’s teams in 2005 European Championship (Soroka & Bergier, 2010), the offensive playing profiles of the top quarterfinalist teams in 1999 World Cup (Konstandinidou & Tsigilis, 2005) and the attacking strategies related to goal scoring opportunities in women’s soccer high level matches (Mara, Wheeler & Lyons, 2012).

In men’s soccer it was already studied the game-related statistics that discriminate winning, drawing and losing teams (Lago et al., 2010; Castellano, Casamichana & Lago, 2012; Moura, Martins & Cunha, 2013). However, there is no published study, of our knowledge, which investigated technical and tactical characteristics in successful and unsuccessful teams in women’s soccer. Information about technical and tactical actions present in women’s high-level international games can contribute to the planning of more efficient training programs.

Therefore, the aim of this study was to analyze technical and tactical characteristics of successful and unsuccessful teams in U-20 Women’s World Cup 2014, held in Canada.

METHODS
In order to carry out this study, all the 32 games that took place in 2014 Women’s World Cup were analyzed. The tournament was composed by five phases: group stage, quarter-finals, semi-finals, play-off for third place and final. From each match were collected the participant teams and the final score of the game. For each team we collected total shots, shots on goal, fouls, corner kicks and ball possession per game. Goals scored in penalty decisions were not considered in this study.

All data were collected on the official website of the Federation Internationale de Football Association (FIFA).

All data were tabulated and arranged in Microsoft Excel worksheet and then exported to MATLAB® 2010 program (The MathWorks Inc., Massachusetts, USA) in which all statistical analyses were performed. Descriptive statistics were used to summarize the collected data. Data are presented in mean ± standard deviation.

Lilliefors normality test was performed to determine if data were well-modeled by a normal distribution. When variables presented a normal distribution, T-test test was used to compare the game-related statistics per games between semi-finalists and non-semi-finalists teams, otherwise Mann-Whitney test was performed. In this comparison the drawing teams were excluded based on the small amount of drawn games (n=5).

The same statistical test, T-test or Mann-Whitney, was used to compare game-related statistics between classified and non-classified teams for the semi-finals. The significance level of 0.05 was adopted.

RESULTS
In the U-20 Women’s World Cup 2014, there were 16 participant teams which played 32 games. We found an average of 3.2 ± 1.4 goals per match, 1.7 ± 1.0 cautions per match and there was no expulsion during the tournament.

In Table 1 are presented the game-related statistics per match of winning and losing teams.
We found that winning teams showed greater ratios of goals scored, total shots and shots on goal per match than the losing teams. Winning teams also showed higher ball possession. Amounts of fouls and corner kicks did not differ between the different results of the match. The same analysis was performed for semi-finalists and non-semi-finalists teams. The characteristics of the classified and non-classified teams for the semi-finals are presented in Table 2.

Table 1
Game-related statistics per match of winning and losing teams in U-20 Women’s Soccer World Cup 2014.

<table>
<thead>
<tr>
<th></th>
<th>Winning</th>
<th>Losing</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals scored</td>
<td>2.5 ± 1.4</td>
<td>0.6 ± 0.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total shots</td>
<td>15.5 ± 6.7</td>
<td>11.1 ± 5.1</td>
<td>0.008</td>
</tr>
<tr>
<td>Shots on goal</td>
<td>9.3 ± 3.9</td>
<td>5.9 ± 3.1</td>
<td>0.001</td>
</tr>
<tr>
<td>Fouls</td>
<td>10.6 ± 4.3</td>
<td>10.7 ± 5.4</td>
<td>0.912</td>
</tr>
<tr>
<td>Corner Kicks</td>
<td>4.9 ± 2.8</td>
<td>3.7 ± 2.3</td>
<td>0.089</td>
</tr>
<tr>
<td>Ball possession (%)</td>
<td>52.0 ± 6.8</td>
<td>48.0 ± 6.8</td>
<td>0.037</td>
</tr>
</tbody>
</table>

Table 2
Game-related statistics per match of classified and non-classified teams for the semi-finals in U-20 Women’s Soccer World Cup 2014.

<table>
<thead>
<tr>
<th></th>
<th>Semi-Finalists</th>
<th>Non Semi-Finalists</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals scored</td>
<td>2.4 ± 1.7</td>
<td>1.1 ± 1.05</td>
<td>0.0005</td>
</tr>
<tr>
<td>Total shots</td>
<td>15.7 ± 6.3</td>
<td>11.8 ± 5.2</td>
<td>0.0107</td>
</tr>
<tr>
<td>Shots on goal</td>
<td>9.5 ± 3.6</td>
<td>6.0 ± 3.2</td>
<td>0.0002</td>
</tr>
<tr>
<td>Fouls</td>
<td>10.9 ± 5.5</td>
<td>10.3 ± 4.2</td>
<td>0.6695</td>
</tr>
<tr>
<td>Corner Kicks</td>
<td>5.2 ± 2.0</td>
<td>3.8 ± 2.7</td>
<td>0.0091</td>
</tr>
<tr>
<td>Ball possession (%)</td>
<td>52.0 ± 6.9</td>
<td>48.8 ± 6.7</td>
<td>0.0671</td>
</tr>
</tbody>
</table>

We found that semi-finalists teams showed greater ratios of goals scored, total shots, shots on goal and corner kicks per match than non-classified teams. No differences were found in amounts of fouls and ball possession between the teams.

DISCUSSION
The aim of this study was to analyze technical and tactical characteristics of successful and unsuccessful teams in U-20 Women’s World Cup 2014. We found that winning teams showed greater ratios of goals scored, total shots and shots on goal per match than the losing teams. We also found that semi-finalists teams presented greater ratios of goals scored, total shots, shots on goal and corner kicks per match than the non-classified teams.

Our study was the first to analyze game-related statistics of winning and losing teams in women’s soccer. Moura, Martins & Cunha (2013) and Lago et al. (2010) showed in men’s soccer that shots, shots on goal, playing time with ball possession and percentage of ball possession are important to discriminate the winning from the drawing and losing teams. The results found in our study in U-20 women’s soccer are in accordance with their previous findings.

Our results showed that winning teams had a higher ratio of shots on goal per match than losing teams. In ac-
According to our findings, Castellano, Casamichana & Lago (2013) and Lago et al. (2010) found that the variable of shots on goal had the greatest discriminatory power in men’s soccer. Winning teams in male and female matches seem to be more offensive than the losing ones. These results highlight the need of tactical development during training programs which may promote more successful attacks, creating more scoring chances and increasing the team’s chances of winning.

Another tactical characteristic analyzed in our study was ball possession. According to Lago & Martin (2007), ball possession is one of the most popular performance indicators in soccer and retaining its possession for prolonged periods of time has been linked to team’s success (Hook & Hughes, 2001). We found that winning teams also showed higher ball possession than the losing ones, corroborating previous studies in men’s soccer (Jones, James & Mellalieu, 2004). A higher ball possession can be linked to fewer passing mistakes and a better tactical strategy. Probably, maintaining ball possession for long periods difficult the opponent’s superiority and it allows creating opportunities for offensive attack and shots.

In our study we also investigated game-related statistics of classified and non-classified teams for semi-finals. We found that semi-finalist teams scored, on average, 2.5 goals per match which was significantly higher than the non-semi-finalists teams. This information allows pointing out, through the team’s performance analysis at the beginning of the championship, the potential teams for the Women’s World Cup semi-finals.

Total shots, shots on goal and corner kicks were also significantly higher in semi-finalist teams. Szwarc (2004) showed similar results in men’s soccer and concluded that successful teams made more shots than the unsuccessful ones. In this context, Armatas et al. (2009) also found that top teams made more shots than the bottom teams in Greek Soccer First League.

On the contrary of our findings about winning and losing teams, there was no difference in ball possession between classified and non-classified teams for the semi-finals and the amount of corner kicks was higher in successful teams than unsuccessful ones. Probably, successful teams have a greater use of corner kicks.

Amount of fouls did not differ between winning and losing, successful and unsuccessful teams. Apparently, in women’s soccer, losing teams do not commit fouls as a strategy to avoid the opponent’s superiority. Besides that, comparing to men’s studies (Castellano, Casamichana & Lago, 2013; Lago et al., 2010), female matches show lower amounts of fouls committed, indicating a less aggressive feature of the game.

The results of the present study are advancing with knowledge about women’s soccer, however it is important to recognize our methodology limitations. The small amount of collected data made impossible to use greater statistical analysis, such as cluster analysis and discriminatory analysis. New studies are necessary, using bigger databases, to discriminate game-related statistics between successful and unsuccessful teams in women’s soccer.

CONCLUSION

This study identified technical and tactical differences between successful and unsuccessful teams in U-20 Women’s World Cup. Winning teams showed a higher amount of shots, shots on goal and ball possession per match. Our results suggest that successful women’s soccer teams have greater offensive strategies which allow them to create more opportunity to shoot, to shoot on goal and, consequently, to score more goals. This information is valuable for coaches to plan more efficient training programs. The ratio of 2.5 goals per match by the semi-finalists teams allows pointing out, through the team’s performance analysis at the beginning of the championship, the potential teams for the Women’s World Cup semi-finals.
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Men Judo Motion Analysis by Weight Classes - Matches Held in 2012 London

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The motions of men Judo players employing a Judo “Throwing technique” known as “Ippon” at the 2012 “London Olympics” were analyzed. Men Judo participants were analyzed according to their weight classes using motion picture data given by The Japan Judo Federation. The purpose of this study is to examine the difference of “Kake” time by weight classes. The motion picture data was disassembled into frame data called AVI, which is a file format developed by Microsoft Corp. The motions performed by participants were analyzed using a software system implemented by us based on “OpenCV”, which is an open source library developed by Intel Corp. The beginning and ending of “Kake” time were defined. Then, the “Kake” time, which is the period of time between the beginning and ending of “Kake” according to judgements known as “Ippon,” were examined. The mean value and standard deviation of the “Kake” time were statistically calculated for all weight classes by using “Excel,” a spreadsheet developed by Microsoft Corp. Then, they were compared. We found no significant difference of “Kake” time because of weight classes.

KEYWORDS: Men Judo, Throwing technique, Ippon, Kake.
INTRODUCTION

The motions of the throwing techniques for men Judo in the “Olympic games” held in 2012 in London were analyzed by using motion picture data given by the Japan Judo Federation. It seemed to us that the “Kake” time of heavier Judo men is longer than that of lighter Judo men. So, the differences of “Kake” time by weight classes were examined. Therefore, the purpose of this study was to examine if there exists a difference of “Kake” time between the weight classes. This is a case study using motion analysis of real Judo using motion picture data. Previous studies examining the motion of Judo were miscellaneous. They were not concerned with actual Judo matches. Studies on throwing techniques, studies on the psychological problems of Judo-Ka, studies on the relationship between Judo and other sports, studies of Judo motion by introducing biomechanics and analyzing them mathematically are reported. Three papers shown below are not the studies based on motion pictures, but they reported Judo throwing techniques. Imamura, et al. (2006) investigated a three-dimensional analysis of the center of mass for three different Judo throwing techniques where the center of the thrown opponent was investigated for “Harai-goshi”, “Seoi-nage”, and “Osoto-gari”. The subjects were four throwers and one faller. All motions were analyzed using a system built by peak performance technologies Inc., Englewood, Corp.. This study did not analyze the motion of Judo techniques. Blais, et al. (2007) described joint dynamics and energy expenditure during the execution of a Judo throwing technique called “Morote Seoi Nage”. They used an ergometer with two force sensors coupled with two force platforms, and six synchronized infrared cameras. Modeling methods limited to “Morote Seoi Nage” were described, but the solution methods were not described. Also, this study did not describe the motions during the matches. Alfonso Gutiérez, et al. (2009) analyzed the most frequent mistakes made in the execution of the Uki Goshi hip throw by adults who have no previous experience in Judo techniques, showing how the observed errors relate in order to provide Judo professionals with a useful technical support tool for the teaching-learning process of subjects having similar characteristics. Sacripanti, (2010) described a biomechanical theory of Judo competition introducing a mathematical theory for all contest sports. A couple of force techniques were introduced showing a second order ordinary differential equation, giving the “Uchi-mata” as an example. However, the method for solving this equation was not given.

METHODS

This men Judo motion analysis was limited to matches using a “Throwing technique” judged as “Ippon.” In general, Judo techniques for “Ippon” are consist of “Throwing technique”, “Joint-locking technique”, and “Choking technique”. The operation of “Joint-locking technique” and “Choking technique” takes longer time than the “Throwing technique”, because of longer offensive and defensive operations. Moreover, sometimes a match was judged as “Ippon” by the accumulation of “Waza-ari” and “Yuko”. Therefore, in this study, the motion pictures studied were limited to those judged as “Ippon” by using the “Throwing technique”. “Kake” time was defined as the period of time between the beginning and ending time of “Kake” motion. The difference of “Kake” time according to the weight classes were examined and statistically analyzed by using motion pictures.

Participants

The “Kake” time of men Judo winners judged as “Ippon” by the “Throwing technique” were statistically analyzed by weight classes. The weight classes analyzed were under 60 kilograms, under 66 kilograms, under 73 kilograms, under 81 kilograms, under 90 kilograms, and under 100 kilograms. Weight category numbers 60, 66, 73, 81, 90, and 100 form the progression of the differences. The difference of weight classes makes an arithmetic progression with a common difference of one. The objective of this study is to examine if there exists a difference of “Kake” time because of the various Judo-Ka’s weight differences.

Equipment

Motion picture data was used to examine men Judo motions. This data was disassembled into frame data called AVI by using “XMedia Record” which is a software library that converts broadcasted motion picture data to AVI. This broadcasted motion picture data consisted of 360 pixels in vertical and 640 pixels in horizontal. The image’s aspect ratio was...
16:9, and the frame rate was 25. This means the frame changes every 0.04 of a second. AVI is a file format for storing audio and video information developed by Microsoft Corp. The motions performed by participants while executing the Judo “Throwing technique” were analyzed by using a software system implemented by us based on “OpenCV,” which is an open source library for computer vision and image processing developed by Intel Corp. This software system has the function to read AVI data and play, inverse-play, fast-forward play, fast-rewind play, and frame-by-frame playback both forward and backward. In addition to these functions, the system can take a snapshot of motion pictures while doing frame-by-frame playback.

**Measuring “Kake” Time**
The beginning of “Kake” time is defined as the time when either one of the aggressor’s feet steps forward to attack. The ending of “Kake” time is defined as the time when the opponent’s back inclines 45 degrees to the ground. In this posture, it is impossible for the opponent to recover his balance. In this manner, the beginning and ending of “Kake” time is able to be defined. So, “Kake” time is defined as the span of time between the beginning and ending of “Kake.” To measure the “Kake” time, the software system we implemented was used. The procedure to measure “Kake” time is as follows:

1. Examine the “Ippon” judgement by “fast forward”.

2. Using the “rewind” function, find the 45 degree posture that indicates it is impossible to recover the opponent’s balance. Then, record the frame number.

3. Using the “rewind” function, find the time when either of aggressor’s foot begins to step forward to attack. Then, record the frame number.

4. Calculate the difference between the of frame numbers.

5. Evaluate “Kake” time as the value of multiplication of 0.04 by the difference of frame numbers.

6. In this manner “Kake” time was measured. The unit of “Kake” time is in seconds.

**RESULTS AND DISCUSSION**

“Kake” time was measured as the difference of the beginning and ending of “Kake” operation using a Judo match judged as “Ippon” by using the throwing technique. “Kake” time was statistically analyzed, and the mean and standard deviation of “Kake” time for every weight class were examined. This analytical method is called descriptive statistics, which uses all the data gathered, and visualizes the features or tendencies within the data.

There were 38 matches for the under 60 kilogram class. 8 matches were judged as “Ippon” by “Throwing techniques”. The mean and standard deviation of “Kake” time for these 8 matches were 1.310 and 0.452 of a second respectively. Among these 8 matches, 5 matches or 68.26%, had a “Kake” time between 0.858 and 1.762 of a second. The shortest “Kake” time was 0.8 of a second. The longest “Kake” time was 2.6 of a second.

There were 39 matches for the under 66 kilogram class. 9 matches were judged as “Ippon” by “Throwing technique”. The mean and standard deviation of “Kake” time for these 9 matches were 1.271 and 0.511 of a second respectively. Among these 9 matches, 6 matches, or 68.26%, had a “Kake” time between 0.760 and 1.782 of a second. The shortest “Kake” time was 0.64 of a second. The longest “Kake” time was 2.36 of a second.

There were 37 matches for the under 73 kilogram class. 9 matches were judged as “Ippon” by “Throwing technique”. The mean and standard deviation of “Kake” time for these 9 matches were 1.234 and 0.288 of a second respectively. Among these 9 matches, 6 matches, or 68.26%, had a “Kake” time between 0.946 and 1.522 of a second. The shortest “Kake” time was 0.76 of a second. The longest “Kake” time was 1.64 of a second.

There were 36 matches for the under 81 kilogram class. 7 matches were judged as “Ippon” by “Throwing technique”. The mean and standard deviation of “Kake” time for these 7 matches were 1.663 and 0.629 of a second respectively. Among these 7 matches, 4 matches, or 68.26%, had a “Kake” time between 1.034 and 2.292 of a second. The shortest “Kake” time was 0.8 of a second. The longest “Kake” time was 2.6 of a second.
There were 33 matches for the under 90 kilogram class. 10 matches were judged as “Ippon” by “Throwing Technique”. The mean and standard deviation of “Kake” time for these 10 matches were 1.508 and 0.411 of a second respectively. Among these 10 matches, 6 matches, or 68.26%, had a “Kake” time between 1.097 and 1.919 of a second. The shortest “Kake” time was 0.88 of a second. The longest “Kake” time was 1.96 of a second.

There were 34 matches for the under 100 kilogram class. 10 matches were judged as “Ippon” by “Throwing Technique”. The mean and standard deviation of “Kake” time for these 10 matches were 1.684 and 0.672 of a second respectively. Among these 10 matches, 6 matches, or 68.26%, had a “Kake” time between 1.012 and 2.356 of a second. The shortest “Kake” time was 1 of a second. The longest “Kake” time was 2.96 of a second.

The above mentioned facts were gathered and depicted as Table 1.

### Table 1
Judo motion analyzed (time is measured in seconds)

<table>
<thead>
<tr>
<th>Weight class (Kg)</th>
<th>Mean “Kake” time</th>
<th>Standard distribution of “Kake” time</th>
<th>Number of matches</th>
<th>Number of “Ippon”</th>
<th>Rate of “Ippon” (%)</th>
<th>Shortest “Kake” time</th>
<th>Longest “Kake” time</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>1.310</td>
<td>0.452</td>
<td>38</td>
<td>8</td>
<td>21.05</td>
<td>0.8</td>
<td>2.60</td>
</tr>
<tr>
<td>66</td>
<td>1.271</td>
<td>0.511</td>
<td>39</td>
<td>9</td>
<td>23.08</td>
<td>0.64</td>
<td>2.36</td>
</tr>
<tr>
<td>73</td>
<td>1.234</td>
<td>0.288</td>
<td>37</td>
<td>9</td>
<td>24.32</td>
<td>0.76</td>
<td>1.64</td>
</tr>
<tr>
<td>81</td>
<td>1.663</td>
<td>0.629</td>
<td>36</td>
<td>7</td>
<td>19.44</td>
<td>0.8</td>
<td>2.60</td>
</tr>
<tr>
<td>90</td>
<td>1.508</td>
<td>0.411</td>
<td>33</td>
<td>10</td>
<td>30.30</td>
<td>0.88</td>
<td>1.96</td>
</tr>
<tr>
<td>100</td>
<td>1.684</td>
<td>0.672</td>
<td>34</td>
<td>9</td>
<td>26.47</td>
<td>1.0</td>
<td>2.96</td>
</tr>
</tbody>
</table>

From Table 1, the differences of mean “Kake” time for every weight class were considered as differences of weight and muscle power. But the difference of “Throwing Technique” and the development of each match affects the “Kake” time. Therefore, it is difficult to consider that the difference of weight and muscle power alone affect “Kake” time. So, the correlations between “Kake” time and the different weight classes were examined. In addition to this, the correlations between standard deviation which shows the variation of “Kake” time and weight classes were examined. Correlation and regression were examined for “Kake” time, standard deviation of “Kake” time, and the rate of “Ippon” using the values depicted in Table 1. Calculated values are depicted in Table 2.

### Table 2
Correlation coefficient and regression analysis

<table>
<thead>
<tr>
<th></th>
<th>Between mean “Kake” time and weight classes</th>
<th>Between standard distribution of “Kake” time and weight classes</th>
<th>Between rate of “Ippon” and weight classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation coefficient</td>
<td>0.811</td>
<td>0.790</td>
<td>0.608</td>
</tr>
<tr>
<td>Regression analysis</td>
<td>0.0108</td>
<td>0.0043</td>
<td>0.1581</td>
</tr>
</tbody>
</table>
From Table 2, we are able to recognize that mean “Kake” time, standard deviation of “Kake” time and rate of “Ippon” have a weak relation to weight classes by examining the correlation coefficient. But by examining regression analysis, mean “Kake” time, standard deviation of “Kake” time and rate of “Ippon,” seem to have no relation to weight classes, if we consider 0.04 of a second corresponds to one frame, and “Kake” time evaluated was the period of time between the beginning of “Kake” and the ending of “Kake” decided manually and subjectively.

CONCLUSION

The motions of “Throwing technique” for men Judo in the “Olympic” held in 2012 in London were analyzed by using motion picture data given by the Japan Judo Federation. Motion pictures were limited to the matches judged as “Ippon” by “Throwing technique”. “Kake” time was defined as the period of time between the beginning and ending time of a “Kake” operation. The difference of “Kake” time by weight classes were examined and statistically analyzed. Number of matches, the mean and standard deviation of “Kake” time, the shortest and longest “Kake” time are described for each weight class. The correlations between mean “Kake” time and weight classes, between standard deviation of “Kake” time and weight classes, and between rate of “Ippon” and weight classes were examined. The regression analyses were performed by using mean “Kake” time, standard distribution of “Kake” time, and rate of “Ippon”. We found no relation between mean “Kake” time, standard deviation of “Kake” time, rate of “Ippon” and weight classes.

REFERENCES


Survey on Attitude Toward Judo — With Japanese University Judo Athletes and Regular Students as Subjects

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This study examined both Japanese university Judo athletes’ and regular students’ perceptions of Judo. An opinion survey was administered to both Judo athletes (n=733) and those students inexperienced in Judo. Using a 5-point scale, each subject answered 20 questions derived from Nakajima et al.’s previous study on people’s perceptions of Judo. With the exceptions of questions 12 and 14, the results indicated there were significant differences found in the remaining 18 items based on the years of experience factor. In the results for Q14, Judo was consistently understood to be a traditional Japanese martial art. For Q12, in which respondents were asked about ear injuries, both subject groups (experienced and inexperienced in Judo) associated this activity with this type of injury.

KEYWORDS: judo, spot, tradition, culture.
**OBJECTIVE**

Judo, which was founded by Master Jigoro Kano, has spread to over 200 countries around the world, and developed to be an Olympic event. On the other hand, Judo has become increasingly competitive since the ranking system was introduced in 2009. As such, some believe the emphasis on winning has become stronger, with the spiritual aspect of honoring propriety, which is the actual essence of Judo, seemingly becoming weaker.

Therefore, this study aimed to examine what kind of image Japanese university Judo athletes and regular students have toward Judo, by conducting an attitude survey.

**METHODS**

**Materials**

For the questionnaire, 20 questionnaire items that employed Nakajima et al.’s preceding study, Study on the research on the image of Judo, was used. Following the coversheet, the subjects were asked to respond to each questionnaire item using a 5-point scale.

**Subjects**

Seven hundred and thirty-three students from 7 Japanese universities participated as the subjects for present study. A total of 733 subjects (male: 320, female: 413), with the number of subjects inexperienced at Judo being 400 (male: 93, female: 307); the number of subjects with experience in Judo was 333 subjects in total; with those having less than 12 years of experience constituting 186 subjects (male: 128, female: 58), while those with 13 or more years of experience constituting 147 subjects (male: 99, female: 48).

**Analysis method**

All the obtained materials were turned into scores and a descriptive statistic (the mean and standard deviation for each item) was calculated. Afterward, the difference in means was examined by conducting a two-way factorial ANOVA using gender and years of experience as factors.

**RESULTS AND DISCUSSION**

Table 1 shows the results of the ANOVA. The horizontal axis shows the main effects of gender and years of experience (multiple comparison) and the mutual interaction effects. Among these two main effects, the gender factor was significant in the 8 items of Q6, Q7, Q10, Q13, Q15, Q17, Q19, and Q20. The multiple comparison (Bonferroni Test) that was conducted on these 8 items showed that the scores of males were higher than those of the females in all of these items except for Q13 and Q20. Based on the tendency found in Q13, “the colors white and blue of Judo uniform”, the necessity of “colors white and blue in Judo uniform” is seen stronger among females. Furthermore, the tendency of Q20: “Judo is a sport” shows that the attitude of Judo being a sport is stronger among females. Based on these results, viewing the 20 items as an entire index shows that it reflects a general difference to the image of Judo based on one’s experience. In other words, it was able to achieve a certain degree of validity.

Furthermore, the duration of judo experience factor was found to have significant differences in 18 items, other than Q 12 and Q14. From the result about Q14, Judo is consistently understood as for the Japanese traditional martial arts. As for the result of Q12 stating the ears injury, the injury has been conceived occurring certainly to this activity among the both the inexperienced people and the Judoin. This negative recognition to the Judo should be resolved by the responsibility for instructors/teachers. Jaggi, U et al. (2015) stated that the ‘martial arts such as Judo, taekwondo and wrestling are regulated, usually athletic duels. The aim is to score better than your opponent or to win. As with any type of sport, athletes in martial arts sustain minor and major injuries, which may have many negative consequences. In addition, sports injuries and their rehabilitation generate high costs to the healthcare system. In contrast to the FIFA 11+ warm-up program, no preventive programs have been postulated for injury prevention in these martial arts’.

**Research method**

The research period was between June and October 2015. The research was conducted after distributing questionnaire sheets to students from the 7 universities and gaining their consent.
The multiple comparison on these results showed a significant difference between the non-experienced group and the other two groups of experienced subjects (the under 12 years group and the 13 years and more group). Although the scores of the inexperienced subjects were high for Q13 and Q20, the experienced subjects showed higher scores for all other 16 items. This means to say that in Q13, the inexperienced subjects showed the tendency to believe that “colors white and blue in Judo uniform” was necessary, and they also had the tendency to view “Judo is a sport” in Q20. These points showed that those who have experience in Judo view it as a form of culture different to sport – in other words, as martial arts – and those without experience tended to view it as a sport.

Furthermore, the reason why females and those without experience perceived “Judo uniform to have colors white and blue” may have been the influence of watching TV (i.e., recent international matches). On the other hand, the results suggest that those with experience in Judo or males tended to feel a sense of unfamiliarity toward this trend. Mr. Yasuhiro Yamashita, vice president of All Japan Judo Federation, stated that this color scheme has a huge benefit to top level international matches in the sense that it prevents erroneous judgement. However, making this color scheme compulsory to kids’ competition may prevent some people from practicing in Judo due to financial reasons. Thus, Mr. Yamashita stated that it was detrimental for the development of Judo, with many Judo instructors in Japan holding a similar opinion. Otherwise, the inexperienced people for Judo could not understand these point.

The mutual interaction effect was significant in the 6 items of Q2, Q3, Q5, Q7, Q12, and Q14. Including the examination of this mutual interaction effect, the points of “quality of being a sport” and the “white and blue in Judo uniform” may need to be examined.

### Table 1

The descriptive statistics and Two-way (gender × judo-experience) ANOVA of image of Judo.

<table>
<thead>
<tr>
<th>variable</th>
<th>mean</th>
<th>S.D.</th>
<th>effect</th>
<th>interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. In Judo, people are always concerned with ‘Ippon’.</td>
<td>3.3</td>
<td>1.2</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q2. When I think of Judo, I think of Ryoko Tani.</td>
<td>4.7</td>
<td>0.7</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q3. Originally, Judo is from Japan.</td>
<td>4.1</td>
<td>0.8</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q4. Judo often hurts your body.</td>
<td>4.2</td>
<td>0.9</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q5. Judo makes your fingers thicker.</td>
<td>3.8</td>
<td>1.2</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q6. Judo is a popular sport around the world</td>
<td>4.8</td>
<td>0.5</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q7. Judo is a martial art.</td>
<td>3.9</td>
<td>1.0</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q8. Judo games require time limitation.</td>
<td>4.2</td>
<td>1.0</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q9. The founder of Judo is Jigoro Kano.</td>
<td>4.2</td>
<td>1.0</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q10. Japan is proud of Judo all over the world</td>
<td>3.5</td>
<td>1.5</td>
<td>(M&gt;F)</td>
<td>Non;②,③</td>
</tr>
<tr>
<td>Q11. Judo is a painful sport.</td>
<td>4.4</td>
<td>0.9</td>
<td>(M&gt;F)</td>
<td>Non;②</td>
</tr>
</tbody>
</table>
Summary
From the above results of the university athlete group and the general student group, it was found that:

1) By gender, females showed a strong tendency to feel the necessity for the “Judo uniform to be white and blue” and to view “Judo as a sport”.

2) In regard to the years of experience, inexperienced people showed the tendency to view the necessity of “Judo uniform to be white and blue” and to view “Judo as a sport”.

3) As the result of Q12 stating the ears injury, the injury has been conceived occurring certainly to this activity among both the inexperienced people and the Judoist. The preventive programs must be postulated for injury prevention in these martial arts.

Table 1
The descriptive statistics and Two-way (gender × judo-experience) ANOVA of image of judo.

<table>
<thead>
<tr>
<th>variable</th>
<th>mean</th>
<th>S.D.</th>
<th>effect</th>
<th>interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q12. Judo practice changes your ears’ shape.</td>
<td>4.1</td>
<td>0.9</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Q13. White and blue Judo uniform are necessary.</td>
<td>4.0</td>
<td>1.1</td>
<td>* (M&gt;F)</td>
<td>*</td>
</tr>
<tr>
<td>Q14. Judo is a part of traditional Japanese culture.</td>
<td>4.4</td>
<td>0.8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Q15. Judo is a cool sport.</td>
<td>3.8</td>
<td>0.8</td>
<td>* (M&gt;F)</td>
<td>*</td>
</tr>
<tr>
<td>Q16. Judo is a fun sport.</td>
<td>3.8</td>
<td>1</td>
<td>—</td>
<td>(M&gt;F)</td>
</tr>
<tr>
<td>Q17. Judo requires a judge to decide a winner.</td>
<td>4.1</td>
<td>1</td>
<td>* (M&gt;F)</td>
<td>*</td>
</tr>
<tr>
<td>Q18. Judo helps you grow as a person.</td>
<td>4.2</td>
<td>0.9</td>
<td>—</td>
<td>(M&gt;F)</td>
</tr>
<tr>
<td>Q19. Judo promotes the development of mental power and</td>
<td>4.3</td>
<td>0.8</td>
<td>* (M&gt;F)</td>
<td>*</td>
</tr>
<tr>
<td>Q20. Judo is a sport.</td>
<td>4.4</td>
<td>1</td>
<td>—</td>
<td>(M&gt;F)</td>
</tr>
</tbody>
</table>

*・・・P<0.05
Multiple range test by Bonferroni

<table>
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<th>REFERENCES</th>
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<tr>
<td>Yamashita, Y. <a href="http://www.yamashitayasuhiro.com/hitokoto/color/">http://www.yamashitayasuhiro.com/hitokoto/color/</a></td>
</tr>
</tbody>
</table>

SURVEY ON ATTITUDE TOWARD JUDO – WITH JAPANESE UNIVERSITY JUDO ATHLETES AND REGULAR STUDENTS AS SUBJECTS
This study reports on the contents of judo training and rehabilitation provided to people with intellectual disabilities at two special needs education schools in Japan. First, Warashibe-Kai, which started in 2010 in Osaka, has fostered activities for improving physical strength and spending one’s leisure time by training courteously while supporting those with mild intellectual disabilities aiming to start work. Second, Judo has been taught since 1969, when it was incorporated into the physical education curriculum at The Tokyo Metropolitan Seicho Special Needs Education School in Tokyo. These case reports reveal that Judo training has positive physical and mental effects on people with intellectual disabilities.

**KEYWORDS:** judo, traditional culture, rehabilitation, education.
INTRODUCTION
Previous studies in Europe and America have reported that judo training can be used as a form of exercise therapy for people with mental and physical disabilities such as cerebral palsy and limb disabilities. However, the effects of judo training for people with disabilities have not been reported in Japan. In Japan, judo became a compulsory subject of study in junior high schools in 2008, preparing an environment for many junior high school students to study judo. However, while the environment has been well established at regular schools attended by individuals without handicaps, this is not the case at special needs schools for those with intellectual disabilities. Essentially, judo training for those with intellectual disabilities in Japan is currently not incorporated to any great extent. We hypothesized that judo training is beneficial for people with disabilities in Japan. The purpose of these case studies was to identify the effect of judo training for people with intellectual disabilities, especially children with autism and Down Syndrome.

METHODS
We investigated the instructional content and results of judo training for people with intellectual disabilities at the following two institutions in Japan:

**Case 1. Warashibe-Kai, Hirakata, Osaka**

**Case 2. The Tokyo Metropolitan Seicho Special Needs Education School, Setagaya, Tokyo**

RESULTS
**Case 1. Warashibe-Kai**
The main objective of judo training targeted at people with intellectual disabilities, starting from 2010, has been as an activity for improving physical strength and spending one’s leisure time, training courteously while supporting those with mild intellectual disabilities aimed at starting work.

**1) Instruction Content**

**a) Etiquette**
In addition to the seated bow, all members read “The Secret of Advancement in Judo” posted on the wall.

**b) Warming Up**
Approx. 10 minutes of warm-up and strength training exercises (to loosen the muscles that become stiff in everyday life). Warm-Up Exercises—full-body stretches.
Exercise Reps—push-ups, sit-ups, back muscle exercises, squats, stamps (10x each)

**c) Repetition Training**
Mainly focuses on osoto-gari (big outer reap), seoi nage (shoulder throw), and ouchi-gari (big inner reap) (10 times, 3 sets).

**d) Breaks (10 minutes)—In order to maintain concentration, frequent breaks are necessary.**

**2) Results**

**a) Using loud voices, performing full-body exercises, building up sweat doing the appropriate amount of exercise, being able to refresh mentally and physically, most people continue practicing for a long time at their own pace.**

**b) Observed improvement in techniques according to each individual.**

**c) For those who have little to say about themselves, when talking about judo, their ability to communicate with family and in the workplace increased greatly.**

**Case 2. Tokyo Metropolitan Seicho Special Needs Education School**
Judo has been taught since 1969 when it was incorporated into the physical education unit. The goals are to “create safety in daily life and instill a basic active attitude,” to “have respect for partners and opponents and have a courteous attitude and posture,” and to “acquire skills.”
1) Instruction Content
All grade levels have 3 months from October to December (20-30 hours/yeara)

a) Improving Basic Physical Fitness
Individual Reinforcement Training
*using a mat (hand use & push, pull, rolling, and falling)

b) Learning Etiquette
Kneeling Position - Sitting with Crossed Legs - Standing Position - Bowing - Meditation

c) Learning Techniques
Ukemi (breaking your own fall; rear, side, and forward-rolling), Kuzushi (off-balancing opponent), Tai-sabaki (defensive body movement), Osoto-gari (big outer reap), Tai-otoshi (body drop), Katamewaza (grappling techniques)

2) Results
a) Students with hyperactive tendencies have become capable of cooperative action through group activities such as observing etiquette and ukemi exercises.

b) Students who have trouble with continuous physical activity due to Down syndrome have been able to build muscle strength through practice of ukemi exercises and sparring.

c) Students with autistic tendencies who have difficulty engaging with a partner and showing consideration to others have come to be able to engage in sparring and extend a friendly hand after executing a throw.

d) Students that build a familiarity with the etiquette and surroundings of judo are able to act cooperatively and naturally learn the traditional culture of Japan.

CONCLUSION
Judo training for people with intellectual disabilities can be seen to have positive physical and mental results when looking at case reports. However, in Japan, research for developments that could be made in this field have not been implemented at present. In the future, developing programs for judo instruction, and additionally, clarifying instruction methods’ effects when applied to judo and their utility in physical and mental rehabilitation is considered an important challenge.

REFERENCES
The availability of data related to the player positions on the court is of paramount importance for technical and tactical analyses in basketball. Given the relevance of this problem, the aim of this study was to evaluate a video-based framework for automatic 3D localization of multiple basketball players. The method proved feasible in the context of official games. Indeed, the obtained root-mean-square error (RMSE) associated with the estimation of the players position was 0.18 m, which, in view of the dimensions of one-half basketball court (14 m x 15 m), attests the accuracy of the introduced framework.

**KEYWORDS:** accuracy, biomechanics, computer vision.
INTRODUCTION
Player detection in basketball is a hard task because of situations such as players occlusions, strong shadows cast by players, and sharp reflections from the polished floor. On the other hand, one must dispose of accurate and reliable estimations of the players position in order to perform technical and tactical analyses (Mcgarry et al., 2002; Perse et al., 2009; Wilhelm et al., 2009). In the present work, a framework for automatic 3D localization of players tailored to basketball is proposed. In the introduced approach, the identification of the players’ heads was performed at the camera image level through image processing and machine learning procedures. Moreover, the 3D reconstruction of the players’ positions was addressed by formulating a combinatorial optimization problem. The proposed method was evaluated through actual data in a task of 3D automatic localization of multiple basketball players. The framework that was evaluated was a result of the master’s degree project (unpublished) which was developed by the Laboratory of Biomechanics and Instrumentation in collaboration with the Center of Operations Research, both at the University of Campinas.

METHODS
The video data (resolution of 1038 x 776 pixels, and sampling frequency of 5 Hz) comprising two games were acquired using three static industrial FireWire cameras (Allied Vision Technologies GmbH©, with 6 mm lens) attached conveniently at the highest places in the gym (near 12 m from the ground, see Figure 1). The method was applied inside of a designated image area (the pre-determined polygons shown in Figure 1), and after correcting the image distortion. Both the Brazilian National Basketball League and the Limeira Basketball Association approved the video data collection.

Figure 1
Framework diagram showing the key tasks for player detection and 3D localization.

The developed framework comprises two parts, as illustrated in Figures 1 and 2. The first one consists in detecting the player (player head identification) at the camera image level. This task was addressed via image processing tools. Indeed, in order to find the player contour, the following steps were carried out: background segmentation, erosion and dilation. A circle Hough transform was adopted to obtain the best circle
by taking head size into account as well as the result provided by a classification performed by an artificial neural network.

The second part of the proposed framework concerns the 3D reconstruction of the players’ positions. In that respect, a constrained combinatorial optimization problem was formulated in order to minimize the re-projection error while maximizing the number of detections. The 3D coordinates of the players related to the basketball court coordinate systems and the calibration were performed using an image-object transformation method (Direct Linear Transformation, Abdel-Aziz, Karara, 1971).

Figure 2
a) Heads enclosed by the Circle Hough Transform, represented by the red asterisks (camera 1, 2, and 3); b) An example of combinatorial optimization considering the head detected: Player 5 (camera 1), player 8 (camera 2), and player 12 (camera 3) that were designed to a given player resulting in 3D reconstruction (color circle is the re-projection onto cameras and court plane); b) Player’s localization on the basketball court.

The evaluation of the framework was conducted to verify the accuracy in the determination of the position on the court. The player position obtained with a manual measurement using the DVideo (Campinas, SP, BRAZIL) system (Barros et al., 2007; Figueroa, Leite, Barros, 2006) by one expertise rater was assumed as the ground truth. The player localization accuracy of the proposed framework was evaluated considering the real distance in meters between the outputs provided by both methods. Descriptive statistical through RMSE (root-mean-squared error) and median were performed for error analysis in players’ position in two situations: firstly, localization solved by optimization and, secondly, localization of remaining point using a priori vertical (axis Z) information.

RESULTS
Error evaluation in the determination of the player position on the court was assessed considering the players present in at least two cameras in first situation (2941 samples). The RMSE in space court reference (axis X, Y and Z) was 0.18 m, and the RMSE in plane court (axis X and Y) was 0.16 m for optimization. The median error, Euclidian distance, in space court were 0.030 m, 0.021 m, and 0.056 m (respectively for axis X, Y and Z). For the remaining (917 samples, second situation) point issues that were not localized in the optimization step, the errors were 0.33 m (RMSE) in space court (axis X, Y and Z) and 0.30 m (RMSE) in plane court (axis X and Y). The median error, Euclidian distance, in space court were 0.171 m, 0.098 m, and 0.075 m (respectively for axis X, Y and Z).
DISCUSSION

Video-based methods for player tracking in team sports (soccer or futsal) take 2D positions into account. However, considering the basketball analysis, kinematic variables that consider the vertical component of player position are fundamental because of the existence of jump actions during the game. Thus, our principal contribution and effort consisted in obtaining the 3D player position.

The accuracy values in determining the player’s position on court proved to be feasible and reliable. A RMSE of 0.18 m can be considered a good result of one considers the dimensions of one-half basketball court (14 m x 15 m). For the sake of illustration, handball players tracking using ceiling cameras provided a RMSE in the player position of 0.28 m near the optical axis and 0.36 m for the court boundary (Pers et al., 2001). An automatic tracking soccer study reported a spatial resolution of 0.3 m (Barros et al., 2006). In the indoor 5-a-side football players tracking (playing surface of 18 m x 32 m), the obtained RMSE was 1.16 m considering the determination of the position and a modal value below 40 cm compared with manual tracking (Needham & Boyle, 2001).

CONCLUSION

A video-based framework for automatic 3D localization of multiple basketball players was proposed and tested in the context of official games. Our proposal comprises a first step of image processing followed by a combinatorial optimization formulation that searches for determining the player position. The introduced framework provided good results in terms of RMSE, and, thus, can be useful when performing technical and tactical analyses in basketball. Moreover, it is worth mentioning that the proposed framework can be useful to other indoor team sports in which a vertical component is relevant.

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