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DIFFERENCES IN GRF EXECUTING FOREHAND TOPSPIN WITH DIFFERENT BALLS

Abstract

In modern table tennis most international competitors favour the forehand top spin as most favourable attacking stroke. Technically correct performance of top spin strike and its power is, of course dependable on the player's knowledge, his motor abilities, his morphological characteristics and especially on his physical preparation. Perfectly performed top spin has to be initiated from the legs and an activation of a proper kinetic chain is therefore the most important part of this stroke.

The aim of this study was to find out if during the forehand top spin strokes with balls of different sizes there are differences in the ground reaction force (GRF). Lack of strength in player's legs can namely produce over time a wide range of injuries.

The comparison of selected parameters proved that the observed differences increase due to increased ball size. In order to hit the ball with more spin, the player must use wider movement path to position a ball on his racket. As bigger ball has at the same speed less spin, players need to execute top spin with more power.

The gathered data should facilitate planning of the physical preparation training process of table tennis players.

Key words: *table tennis, GRF, forehand top spin*

1 Introduction

Performance in table tennis and also in any sporting event is the result of a number of factors, which include the amount and structure of training performed, the body's predisposition and adaptation to the training, motivation level, facilities, socio-cultural background etc. Therefore, physiological parameters only account for a portion of any performance, and so the role of any exercise physiologist is also similarly limited. Through fitness testing, the factors involving physiological processes, over which there is some control, can be measured and ultimately improved upon. Competition is the ultimate test of performance capability, and is therefore the best indication of training success. Nevertheless, when trying to maximize performance, it is important to determine the player's ability in individual aspects of performance. Fitness testing attempts to measure individual components of performance, with the ultimate aim of studying and maximizing the player's ability in each component (Kondrič, & Furjan-Mandić, 2002).

The importance of strength in table tennis is not always obvious. However, the need to produce powerful strokes, the need for maximum power is apparent. From this point of view we can observe power as the result of two factors: strength to produce the force and speed to increase the rate at which the force can be applied (first of all by spin on spin game).

It was expected that the new, bigger ball will not only make it better visible for players and spectators but will as well to some extend reduce the speed in the game. At the beginning it was the case, not quite as much as expected, but due to development of equipment and playing techniques today the speed in the game is quite the same as before with the smaller ball and there is still the tendency to make the game even faster (Kondrič, Furjan-Mandić, Medved 2003; Furjan-Mandić, Kondrič, Kasović 2003). It seems necessary to run experiments to find out possibilities to reduce the speed of the ball without any drastic changes of equipment and rules, without making table tennis more expensive as it already is. On the other hand, even though that we always read how safe our sport is, we have to admit that there are some injuries which are caused due to improper movements regarding different strokes and footwork (Ogimura, 1973; Trupković, 1978; Hiruta et all, 1992) .

For every action, according to Newton's 3rd Law of Motion (Law of Action and Reaction), there is an equal and opposite reaction to every action. In other words, the action to the ground is always accompanied by a reaction from it. Due to the gravity, we constantly maintain contact with the ground, and in this process, there occur interactions between the body and the ground. The reaction force supplied by the ground is specifically called the **ground reaction force** (**GRF**), which is basically the reaction to the force the body exerts on the ground.

The ground reaction force is an important external force acting upon the human body in motion. We use this force as propulsion to initiate and to control the movement.

The aim of our research is to find out if there are differences between forehand strokes performed with different balls. The gathered data should show us a difference in GRF providing of different strokes with different balls.

2 Methods

2.1 Design

To design an optimal movement for table tennis players executing top spin stroke, it is essential first to establish exactly how a player makes his movements regarding leg and centre of gravity. We measured the kinematic parameters of movements between the forehand top spin strokes executed with different balls. The greater turn (in stride) should ensure the greater ground reaction impact forces, which should also assist in generating unprecise strokes.

2.2 Participants

Ground reaction forces (GRF), as well as kinematic parameters were measured on a professional male table tennis player, a member of the Slovenian national team. The data were collected and analysed both visually and quantitatively.

2.3 Materials

"Kistler" force platform (model 9281 B11 – dimensions 60 x 40 cm) was used to collect the ground reaction force (GRF) data. There are four 3-axial force sensors embedded in the plate so that one can measure the ground reaction force in 3 axes: antero-posterior axis (*X* axis), transverse axis (*Y* axis), and vertical axis (*Z* axis) with the 1000 Hz sampling frequency. The force platform was installed in the middle of one side of the table tennis table in the Biomechanics Laboratory at the Faculty of Kinesiology in Zagreb, Croatia. The signal conditioner/amplifier was interfaced with a sampling system interfaced to a computer. The "Elite 2002" (BTS Bioengineering, Milan, Italy) biomechanical measurement system was used for kinematic data collection and analysis. During measurements 2 high speed video cameras interfaced to a real time automated video based tracking system were used. The cameras were positioned to obtain a side (sagittal – 2 cameras from left and from right) and rear (frontal – from back) view of the centre of gravity and legs.

2.4 Procedure

The measurements were conducted during forehand top spin strokes performed with the table tennis ball machine. The participant was filmed as he executed the strokes. To ensure the same conditions for all the performances (the same approaching ball trajectory), a table tennis machine was used. Prior to recording the movement, reflective markers were placed on the subject's left and right lower extremity and above the hips.

In this study we have used also a method of kinematic analysis, which enables the precise registration and evaluation of the most significant parameters of forehand top spin strokes. Those parameters will be described in other article.

2.5 Methods for measured signal processing

Averaged GRF signals were translated into numerical ASCI format and stored into the computer. SPSS statistical package was used for statistical signal processing.

The mean value of averaged kinematic data was calculated for each analyzed stroke. Descriptive statistical parameters (min, max, mean, SD) were calculated for these data. Analysis of variance (ANOVA) was used for calculating differences between measured parameters using two ball sizes.

3 Results

At first glance, it is obvious that there are certain differences in executing forehand topspin stroke with different balls.

The group means, standard deviations, and ranges for all GRF temporal and amplitude variables across trials are available by the authors. For all variables, at both 38mm and 40mm balls, the between-subject effect was significant (P<.05).

The Wilcoxon test is a nonparametric test that compares two paired groups. If the ***p*** value is small, we can reject the idea that the difference is due to chance, and conclude instead that the populations have different medians. If the ***p*** value is large, the data do not give us any reason to conclude that the overall medians differ.

Table 1: Wilcoxon matched pairs test results between variables Fz max 38 and Fz max 40.

		Wilcoxon Matched Pairs Test (Table tennis.sta) Marked tests are significant at p <,05000		
Pair of Variables	Valid N	T	Z	p-level
Fz_max_38 & Fz_max_40	9	5,000000	2,073221	0,038153

Variables represent maximal GRF peak in vertical direction with two different sizes of ball, 38 and 40 millimeters.

Graphic 1: Graphic description median values of maximal GRF peak in vertical direction two sizes of ball, 38 and 40 millimeters.

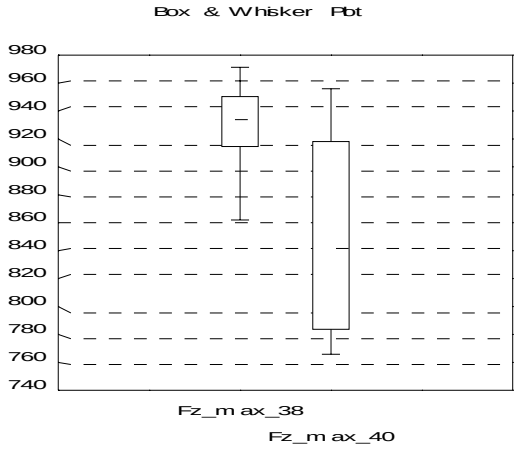


Table 2: Wilcoxon matched pairs test results between variables Fx max 38 and Fx max 40.

		Wilcoxon Matched Pairs Test (table tennis.sta) Marked tests are significant at p <,05000		
Pair of Variables	Valid N	T	Z	p-level
Fx_max_38 & Fx_max_40	9	3,000000	2,310161	**0,020880**

Variables represent maximal GRF peak in antero-posterior direction with two different sizes of ball, 38 and 40 millimeters.

Graphic 2: Graphic description median values of maximal GRF peak in antero-posterior direction two sizes of ball, 38 and 40 millimeters.

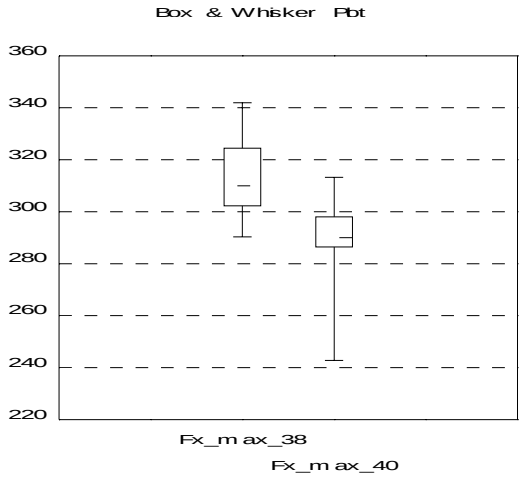
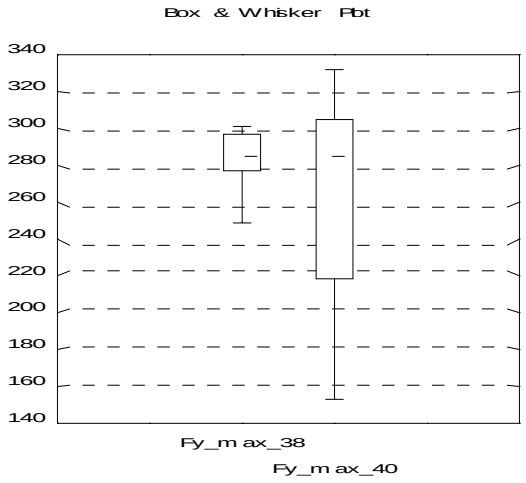


Table 3: Wilcoxon matched pairs test results between variables Fy max 38 and Fy max 40.

		Wilcoxon Matched Pairs Test (Table tennis.sta) Marked tests are significant at p <,05000		
Pair of Variables	Valid N	T	Z	p-level
Fy_max_38 & Fy_max_40	9	21,00000	0,177705	0,858955

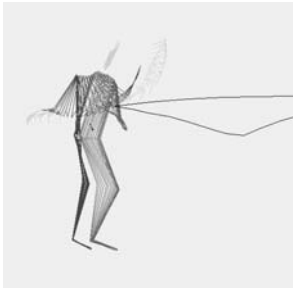
Variables represent maximal GRF peak in transverse direction with two different sizes of ball, 38 and 40 millimeters.

Graphic 3: Graphic description median values of maximal GRF peak in transverse direction two sizes of ball, 38 and 40 millimeters.



The loading rate is important since it reflects the force development rate during impact phase. Loading rate is closely related to the hardness of the shoe sole and the executing of the stroke.

4 Discussion



Although the value of strength in table tennis is no longer an issue of debate, we should be careful not to work on development of massive strength exclusively. Our first concern should be to ensure all-round strengthening of the body and herewith to avoid injuries. When selecting exercises for the strengthening programme, an analysis of movements involved in a particular stroke, in terms of type, speed, direction, etc., should be done in order to be sure which groups of muscles are involved in these movements.

Special exercises should be designed to approximate as closely as possible the pattern and rate of movements of an actual table tennis stroke execution. This will recruit (activate) and train stroke-related groups of muscles thus enhancing their specific neuro-muscular functions needed for a particular performance. Nevertheless, we must not forget that movement acceleration of a joint involved in a particular stroke will depend on the state of certain muscles, which can influence the joint's degree of flexibility. From this point of view, it is obvious that both the ligamentous structures and muscular ability to contract and relax are important (Nigg, 1985). Therefore, it is essential that table tennis players have good flexibility to assist movement and to control a particular stroke performance. It is also well established that

muscle damage can be prevented by training, whether it involves concentric (Bosman et al., 1993) or eccentric exercise (Clarkson, & Tremblay, 1988; Balnave, & Thompson, 1993).

Ground reaction forces (GRF) play a major role in executing top spin. The greater the usable forces the greater the speed that one can attain. Thus how to generate effective GRF is the key how to give a ball more spin.

The practical problem of measuring characteristics of table tennis players during sportive activity has meant that the majority of assessments have been carried out in the laboratory and not in the practice hall at the table (Medved, 2001). However, many sports, including also table tennis, require intermittent exercise, and such tests therefore represent artificial situations.

Considerable confusion sometimes exists about the origin of the forces measured by a force platform. The best way to understand these is to think of the force platform as a whole-body accelerometer. Since Force = mass x acceleration (Newton's 2nd Law of Motion), any acceleration of the body will be reflected in a reaction when at least one foot is on the ground. An upwards acceleration (as occurs at performing top spin stroke) will be reflected in an increase in the vertical load (weight) recorded, while a downwards acceleration will reduce the effective body weight. We have to take into account that a downwards deceleration (such as occurs at initial contact) equals to upwards acceleration, and vice versa.

In our research we did not take into account the rubber gluing although it could have affected the measured parameters. Namely, several layers of glue can change the characteristic of rubber due to which velocity of the ball can be enhanced.

5 Conclusion

It is important to document the strength of forward flexion, abduction, external rotation, and internal rotation.

The desirability of a minimum quantity of strength in table tennis has been for long recognized. Unfortunately the advantages of maximum levels of strength in table tennis were not recognized by all physical educators, athletes and coaches. This neglect of the strength factor was the result of an unscientific acceptance by almost everyone concerned that the development of large amounts of strength in the musculature inevitably resulted in a condition known as muscle-bound. Being muscle-bound was supposed to limit both range and speed of table tennis strokes.

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