



ORIGINAL SCIENTIFIC ARTICLE

ELECTROMYOGRAPHICAL ANALYSIS OF TABLE TENNIS FOREHAND STROKE USING DIFFERENT BALL MATERIALS

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Accepted for Publication: May 18, 2022

Published: June 25, 2022

DOI: 10.17309/tmfv.2022.2.15

Abstract

Research purpose. This study aimed to determine the EMG analysis of forehand topspin using different ball materials.

Materials and methods. For the purposes of this study, seven male university-level table tennis players who were right-hand dominant players (age 21.1 ± 2.4 years, height 162.6 ± 6.8 cm, mass 61.8 ± 3.2 kg) with at least 6 years of playing experience were selected. The selected participants were physically active and had no physical injuries. The study was approved by the research committee. Pectoralis Major (PM), Deltoid Anterior (DA), Latissimus Dorsi (LD), Biceps Brachii (BB), Extensor Carpi Radialis (ECR), Flexor Carpi Radialis (FCR) muscles were selected for the electromyographical study. One of the EMG signals variable Root Mean Square was measured in all muscles, through which the maximum muscle involvement was evaluated. For each assessed muscle and both ball materials, the mean value of Root Mean Square EMG signals was computed. For descriptive statistics, minimum, maximum, mean, and standard deviation were used, and a t-test was used as a statistical technique.

Results. The level of significance was set at 0.05. Results of the study showed no significant difference in EMG variable Root Mean Square between celluloid and poly plastic ball material on selected muscles.

Conclusions. We conclude that the biceps brachii and extensor carpi radialis are important muscles for the forehand topspin because they are responsible for flexion of the arm and work strongly in the action of gripping in the performance of quick forehand spin strokes.

Keywords: electromyography, table tennis, forehand topspin, root mean square, celluloid balls, poly plastic balls.

Introduction

Today's sports training program, which includes table tennis, physical conditioning, and strength training, as well as advanced fitness training diagnostic methods, have now become significantly important (McCann & Bigliani, 1994). Table tennis is a vigorous activity that needs tactical awareness, as well as cognitive and motor preparation (Bańkosz & Winiarski, 2017). It is quick and requires a fast response. Spinning the ball changes its path and minimizes the possible alternatives to a competitor, providing the player a major benefit (Zagatto et al., 2018).

The International Table Tennis Federation changed the ball material from celluloid to polyplastic in 2014 (Kuneth, 2014). "Balls that do not include celluloid" were identified as polyplastic balls (Kuneth, 2020). Celluloid balls were considered to be costly and fragile, causing a fire issue while transporting, that's why this new material (polyplastic) was introduced (Huges, 2014).

The ITTF equipment committee conducted a study on polyplastic and celluloid balls material comparison (Huges, 2014; Kuneth, 2014; Paul, 2015). The polyplastic balls were found to have a greater vertical speed but a slower horizontal speed than celluloid balls (Lee, 2020). The fundamental issue for the modification in ball material, according to ITTF President Adam Sharara, is to decrease the game's speed to make it more viewer-friendly (Kuneth, 2014). Due to the slowing down of the match, various regulations and ball

materials have been changed in present table tennis. A lot of elite players focused on the offensive or attacking style of play (Wang et al., 2018). In table tennis, the forehand topspin is the most dominant offensive shot (Seemiller & Holowchak, 1997). To win a game, attacking players must be successful in generating racket force on the forehand side because a faster forehand racket movement results in a quicker post-impact ball velocity, greater post-impact ball spin, or maybe both, that would be the fact (Iino & Kojima, 2011).

Nowadays, sports are becoming more professional, because we use a lot of technology to uncover flaws to stay on top in the modern world.

Electromyography (EMG) is also used for providing the first functional classification of certain muscles based on the table tennis technique (Petrofsky, 1979). Few studies have been conducted on EMG techniques to evaluate the kinematics of table tennis strokes (Tsai et al., 2010) as well as muscle EMG activity patterns of table tennis forehand shots (38mm and 40mm). They compare muscle patterns while playing with various ball sizes (Kondrič, Miran, Furjan-Mandic, Gordana, Medved, 2006). However, no scientific research has been conducted on muscular involvement using differences in table tennis ball material (celluloid and polyplastic). As a result of this knowledge gap, the authors decided to conduct this research study.



Figure 1. Surface electromyography (Bioengineering, 2011)

When we look at the muscular involvement of the forearm muscle with different ball materials (celluloid and polyplastic), we can identify which muscle is more involved during the forehand topspin and which muscle is more advantageous for performance improvement.

The goal of this research is to see how the forearm muscles Pectoralis Major, Deltoid Anterior, Latissimus Dorsi, Biceps Brachii, Extensor Carpi Radialis, and Flexor Carpi Radialis interact during forehand topspin skill using different ball materials.

Material and methods

Study participants

This study included seven male national-level table tennis players who were right-handed dominant (Age 21.1 ± 2.4 years, Height 162.6 ± 6.8 cm, Bodyweight 61.8 ± 3.2 kg). All the participants had at least 6 years of playing experience at the time of data collection. The participants were physically

active, and there were no reports of the recent upper limb, neurological or ligament damage. All the participants were briefed about the purpose and process of data collection and they provided their written informed consent for participation. The study was approved by the Departmental Research Committee of Lakshmibai National Institute of Physical Education, Gwalior.

Test Administration

During the warm-up, participants performed ten minutes of dynamic stretching. Pectoralis Major (PM), Deltoid Anterior (DA), Latissimus Dorsi (LD), Biceps Brachii (BB), Extensor Carpi Radialis (ECR), Flexor Carpi Radialis (FCR) were selected for assessment. The SENIAM (Surface Electromyography for Non-Invasive Assessment of Muscle) group's recommendations were followed for the procedure of electrode placement on the muscles. Wireless surface electromyography with eight channels (Bioengineering, 2011a) was used for the acquisition of EMG signals from the selected upper extremity muscles.

During a 40s forehand topspin with balls composed of two different materials, the measurements were taken (20 seconds for celluloid balls and 20 seconds for poly-plastic balls). To ensure that all of the performers would be in the same setting, a table tennis Robo machine was used (Newgy's Pro Digital Robo-Pong Table Tennis Robot). Electrodes were placed on the right side of the participants' bodies due to their right-handedness. The contraction intensity and duration of activation were measured.

The EMG signal size method is a standardized approach for detecting, amplifying, and registering bioelectrical activity differences in skeletal muscle (Halaki & Gi, 2012a). Two electrodes are placed beside the muscular fibers at the midpoint of the studied muscle at a standardized distance of 3 cm, using a different method of detection (center to center located). Differential detection eliminates noise (Latasa et al., 2019). For signal recording and interpretation, the bio-mechanical device (Bioengineering, 2011b) was used.

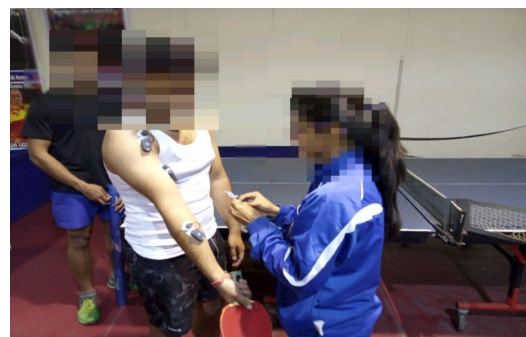


Figure 2. Placement of Electrode on Specific Points

Data analysis

Analysis of the EMG signals was carried out in BTS EMG Analyzer software (version 2.9.40.0). The RMS EMG signals were band-pass filtered using the Butterworth smoothing technique with a lower cut-off frequency of 20 Hz and a higher cut-off frequency of 400 Hz (Halaki & Gi, 2012b) and include: electrode configuration (distance between electrodes as well as area and shape of the electrodes).

Based on Root Mean Square EMG signals measured in all muscles, the maximum muscle involvement was evaluated. For each assessed muscle and both ball materials, the mean value of Root Mean Square EMG signals was computed. Range, mean and standard deviation were reported as descriptive statistics. The data were compared using the t-test. The SPSS software was used to perform all statistical procedures. Significance was accepted at $p < 0.05$.

Results

In Table 1 During forehand topspin using celluloid ball Extensor Carpi Radialis muscles showed maximum involvement (469.31) and Lattismus Dorsi showed minimum involvement (169.04). For polyplastic ball Biceps Brachii, muscles showed maximum involvement (433.81), and Lattissimus Dorsi involved minimum (60.08). The maximum deviation is found in Flexor Carpi Radialis (celluloid ball) and deltoid anterior (polyplastic ball).

Table 2 shows the significant values of equality of variances on both ball materials root mean square data. All values were greater than the .05 level which shows the equality of variances for both celluloid and poly-plastic balls. The obtained results from Table 2 showed no significant difference in selected muscles Root Mean Square using celluloid and polyplastic ball material as p-values of these is $> .05$.

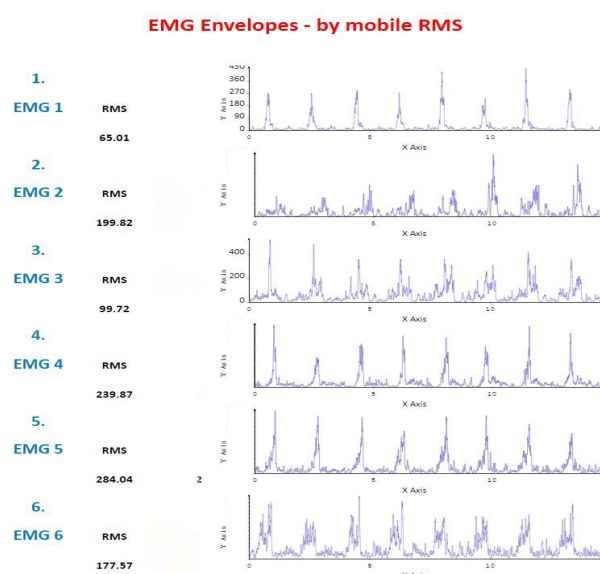


Figure 3. Raw EMG Signal of Muscles Contraction

Figure 3 showed the EMG signals, Root Mean Square (RMS) of muscles while forehand topspin, figure 4 showed the descriptive values of muscles RMS with celluloid and polyplastic ball.

Table 1. Descriptive statistics of Celluloid and Polyplastic balls on Root Mean Square

Muscle	N*	Range (EMG Signal)				Mean		SD [^]	
		Max.		Min.					
		Celluloid	Polyplastic	Celluloid	Polyplastic	Celluloid	Polyplastic	Celluloid	Polyplastic
Pectoralis Major	7	179.56	194.43	70.49	68.31	137.38	135.13	42.10	40.51
Deltoid Anterior	7	414.11	391.61	78.68	89.08	235.35	232.25	114.83	110.60
Latissimus Dorsi	7	169.04	151.49	69.51	60.08	104.34	92.49	40.54	35.14
Biceps Brachii	7	456.53	433.81	169.76	172.95	334.64	315.14	105.31	95.01
Extensor Carpi Radialis	7	469.31	339.66	173.76	176.79	297.87	271.06	95.18	56.39
Flexor Carpi Radialis	7	461.90	387.60	103.60	116.36	216.32	201.02	116.86	93.06

N* Number of Participants; Max. Maximum Range; Min. Minimum Range; SD[^] Standard Deviation

Table 2. Results of t-test on selected muscles Root Mean Square using Celluloid and Polyplastic Balls

Variables			Levene's Test	T-test for equality of means			
			Sig.	t	df	Sig. (2-Tailed)	Mean Difference
RMS	Pectoralis Major	Equal Variances Assumed	0.881	0.14	12	0.88	3.35
RMS		Equal Variances Assumed	0.945	0.51	12	0.96	3.10
RMS	Deltoid Anterior	Equal Variances Assumed	0.672	0.58	12	0.57	11.85
RMS		Equal Variances Assumed	0.818	0.36	12	0.72	19.31
RMS	Biceps Brachii	Equal Variances Assumed	0.385	0.64	12	0.53	26.81
RMS		Equal Variances Assumed	0.882	0.27	12	0.79	15.30
RMS	Extensor Carpi Radialis	Equal Variances Assumed					
RMS		Equal Variances Assumed					
RMS	Flexor Carpi Radialis	Equal Variances Assumed					
RMS		Equal Variances Assumed					

RMS – Root Mean Square; t – Obtained Value of t; df – Degrees of Freedom; Sig. (2-Tailed) – Significance Level

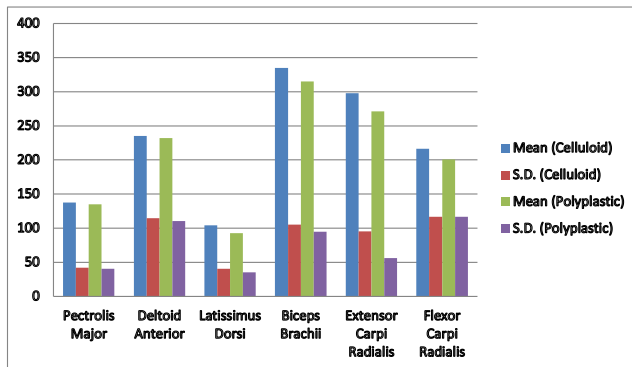


Figure 4. Mean and Standard Deviation (S.D.) values of Root Mean Square on Celluloid ball and Polyplastic ball on selected muscles

Discussion

Earlier gathered information on table tennis ball behavior mostly concerned celluloid balls, which are being widely used since their introduction around 1900 (<http://www.ittf.com/media/History/TimelineHistory.pdf>). The International Table Tennis Federation (ITTF) modified the ball material from celluloid to “polyplastic” for most international tournaments conducted from July 2014. “Balls that do not include celluloid” were defined as polyplastic balls (Huges, 2014; Kuneth, 2014; Paul, 2015).

With varied ball materials (celluloid and polyplastic), we looked at muscle activity during the forehand topspin shot. This study compared the Root Mean Square EMG signal value, which measures physiological activity during contraction.

The findings of the study showed that there was no significant difference found in selected muscles i.e. Pectoralis Major, Deltoid Anterior, Latissimus Dorsi, Biceps Brachii, Extensor Carpi Radialis, Flexor Carpi Radialis muscles' Root Mean Square value using different ball material (Celluloid and Polyplastic ball). ITTF changed the ball material from celluloid to polyplastic balls, (Paul, 2015) Because table tennis balls are light and have a low density, any differences in material, size, or sphericity are likely to influence the ball's trajectory as well as the interactions between the ball, table, racket, and players' responses (Kei et al., 2019). The minimal changes in kinematics reaction to topspin might be explained by the same changes in speed and spin of both types of balls (celluloid and polyplastic) at ball-table contact (Lee, 2020).

Polyplastic balls had a higher speed increase (0.69 %) and a lower spin decrement (0.19 %) after impact with the table tennis surface than celluloid balls (Chen & Huang, 2020). Differences in kinematic reactions to different ball materials were identified when players rebounded backspin shots. Players supinated their rackets 2.23 % ever more produced 3.37 % reduced ball to Polyplastic spin while returning Polyplastic balls than when returning celluloid balls, showing a quick response to the lower spin rate of Polyplastic balls. The absence of variations in kinematic reaction to topspin might be explained by the similar changes in speed and spin of both types of balls upon ball table impact (Iino et al., 2018; Kondrić et al., 2013; David Paár, 2019).

The descriptive statistics of the study showed, maximum RMS (Root Mean Square) for Extensor Carpi Radialis muscle

(469.31) and minimum for Lattissimus Dorsi muscle (169.04) during forehand topspin using a celluloid ball. For the polyplastic ball, the Biceps Brachii muscles showed maximum RMS (Root Mean Square) (433.81) and Latissimus Dorsi showed minimum (60.08). The maximum RMS (Root Mean Square) deviation is found in Flexor Carpi Radialis (celluloid ball) and Deltoid Anterior (polyplastic) muscles.

The analysis of results supports the variations in maximum and minimum voluntary muscular contraction; for slower balls with backspin, as in the case of a service, polyplastic balls are predicted to endure more deceleration upon impact with the table than celluloid balls. Polyplastic balls, on the other hand, are predicted to experience higher acceleration upon impact with the table tennis surface than celluloid balls for quicker balls with more topspin (Iino & Kojima, 2016).

When plastic balls strike the table, they are expected to accelerate more than celluloid balls since they are faster and have more topspin. Because the initial conditions have a large effect on the ball's behavior, testing under various initial factors is necessary to know the properties of each type of ball (Ozaki, 2017).

As the findings of this study showed no significant difference in RMS (Root Mean Square) EMG signals using forehand topspin against backspin balls. Many more studies should be done to understand the effects of ball spin more comprehensively. One limitation of this study is that the participants of this study may not be enough to find possible significant effects of forehand topspin using different ball materials. The participants were recruited from national-level table tennis players.

Different types of styles of play of forehand topspin from the players may be the reason for insignificant results. To establish more definitive results on the examination of EMG during table tennis forehand topspin using different ball materials, more research with a greater number of participants recruited from bigger populations would be required.

Conclusion

The observed results and graphical displays from the research showed that there is no significant difference in activity of the analyzed muscles while using different ball materials for forehand topspin. We conclude that the biceps brachii and extensor carpi radialis is an important muscle for the forehand topspin because it is responsible for flexion of the arm and works strongly in the action of gripping in the performance of quick forehand spin strokes (Buckley & Kerwin, 1988). From this point of view, greater interest is to be paid to the improvement of this muscle in the physical training of the table tennis players. Qualified table tennis players should therefore increase the muscles training that is wanted for their particular style of play after they have set up a large basis of physical fitness.

Acknowledgement

The researchers would like to thank all the players who participated in the study. Table tennis and the research facility at LNIPE are acknowledged for providing instruments during data collection. More thanks to the Department of exercise physiology and Table Tennis group for equipment assistance.

Conflicts of interest

The authors declare no conflict of interest.

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ЕЛЕКТРОМІОГРАФІЧНИЙ АНАЛІЗ УДАРУ ВІДКРИТОЮ РАКЕТКОЮ В НАСТІЛЬНОМУ ТЕНІСІ З ВИКОРИСТАННЯМ РІЗНИХ МАТЕРІАЛІВ М'ЯЧА

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Реферат. Стаття: 6 с., 2 табл., 4 рис., 25 джерел.

Мета дослідження. Дослідження мало на меті встановлення показників ЕМГ-аналізу удару відкритою ракеткою з верхнім обертанням з використанням різних матеріалів м'яча.

Матеріали та методи. Для складання цього дослідження були відібрані сім гравців у настільний теніс рівня університетської спортивної команди чоловічої статі, які володіли правою рукою краще, ніж лівою, (вік $21,1 \pm 2,4$ року, зріст $162,6 \pm 6,8$ см, вага $61,8 \pm 3,2$ кг) та мали принаймні 6 років досвіду гри. Відібрані учасники були фізично активними та не мали фізичних травм. Дослідження було затверджене комітетом із наукових досліджень. Для електроміографічного дослідження були вибрані такі м'язи: великий грудний м'яз (Pectoralis Major, PM), передній пучок дельтоподібного м'яза (Deltoid Anterior, DA), найширший м'яз спини (Latissimus Dorsi, LD), двоголовий м'яз плеча (Biceps Brachii, BB), променевий м'яз-розгинач зап'ястка (Extensor Carpi Radialis, ECR), променевий м'яз-згинач зап'ястка (Flexor Carpi Radialis, FCR). Середньоквадратичне значення змінної одного з ЕМГ-сигналів вимірювали на всіх м'язах, завдяки чому оцінювали максимальну задіяність м'язів. Для кожного оцінюваного м'яза та обох матеріалів

м'яча обчислювали середнє значення середньоквадратичних значень ЕМГ-сигналів. Для описової статистики використовували мінімальні, максимальні, середні значення та величину стандартного відхилення, а як статистичний метод використовували t-критерій Стюдента.

Результати. Рівень значущості був заданий значенням 0.05. Результати дослідження показали відсутність суттєвої відмінності в середньоквадратичному значенні змінної ЕМГ на вибраних м'язах між такими матеріалами м'яча, як целулоїд і полімерна пластмаса.

Висновки. Ми дійшли висновку про те, що двоголовий м'яз плеча та променевий м'яз-розгинач зап'ястка є важливими м'язами для виконання удару відкритою ракеткою з верхнім обертанням, тому що вони відповідають за згинання руки та інтенсивно працюють у процесі дії з міцного утримування під час виконання швидких ударів відкритою ракеткою з обертанням.

Ключові слова: електроміографія, настільний теніс, удар відкритою ракеткою з верхнім обертанням, середньоквадратичне значення, целулоїдні м'ячі, м'ячі з полімерної пластмаси.

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Cite this article as: Maheshwari, A., Pandey, G., Shukla, M., Rawat, V. S., & Yadav, T. (2022). Electromyographical Analysis of Table Tennis Forehand Stroke Using Different Ball Materials. *Теорія та методика фізичного виховання*, 22(2), 249-254. <https://doi.org/10.17309/tmf.v2022.2.15>

Received: 23.04.2022. Accepted: 18.05.2022. Published: 25.06.2022

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