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THE INFLUENCE OF BALL ELASTICITY ON THROWING SPEED AND GRIP STRENGTH IN FEMALE HANDBALL PLAYERS

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ABSTRACT. Introduction: This study examines ball elasticity's impact on throwing speed and palmar strength in female handball players. **Objective:** We hypothesize that ball elasticity influences throwing speed and palmar strength. **Methods:** Nine players were grouped by ball elasticity and underwent grip strength measurements, throws, and exercise. **Results**: Exercise had no significant throwing speed effect; palmar strength decreased. Elasticity showed minimal differences, but hard balls slightly impacted post-exercise speed. **Conclusion:** Exercise impacted palmar strength, but not throwing speed. Elasticity subtly affected post-exercise speed.

Keywords: *Ball Elasticity, Throwing Speed, Palmar Strength, Handball, Exercise-Induced Fatigue*

REZUMAT. *Influența elasticității mingii asupra vitezei de aruncare și a forței de strângere a mâinii la jucătoarele de handbal.* Introducere: Acest studiu examinează impactul elasticității mingii asupra vitezei de aruncare și a forței palmare la jucătoarele de handbal. **Obiectiv**: Emitem ipoteza că elasticitatea mingii influențează viteza de aruncare și puterea palmară. **Metode**: Nouă jucători au fost grupați în funcție de elasticitatea mingii și au fost supuși măsurătorilor de forță de prindere, aruncări și exerciții. **Rezultate**: Exercițiul nu a avut un efect semnificativ asupra vitezei de aruncare; puterea palmară a scăzut. Elasticitatea a arătat diferențe minime, dar mingile dure au afectat ușor viteza post-exercițiu.

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Concluzie: Exercițiul a afectat forța palmară, dar nu viteza de aruncare. Elasticitatea a afectat subtil viteza post-exercițiu.

Cuvinte cheie*: elasticitate a mingii, viteză de aruncare, forță palmară, handbal, oboseală indusă de exercițiu*

INTRODUCTION

Handball is a dynamic and physically demanding team sport that requires a unique combination of technical skills, physical attributes, and strategic thinking (Gandevia,2001; Steib et al.,2013). As one of the most popular team sports worldwide, handball garners significant attention, especially in its female variant. The success of a handball team hinges upon the prowess of its players in various aspects, such as throwing accuracy, strength, and overall hand function (Barbieri et al., 2017). This study delves into a comprehensive examination of the female handball player model, with a specific focus on two pivotal factors: throwing strength and palmar dynamometry.

The act of throwing in handball involves intricate biomechanics and muscular coordination. The force exerted during a throw is a critical determinant of the accuracy and speed of the projectile (Thorlund et al., 2008). Furthermore, a player's ability to maintain consistent throwing strength throughout a match influences their overall performance and the team's success. This study aims to unravel the nuances of throwing strength in female handball players, considering factors such as muscular development, technique, and training regimens (Foster et al., 2001).

In addition to throwing strength, palmar dynamometry, which assesses grip strength, plays a pivotal role in a handball player's overall performance. A player's grip strength can significantly impact their ability to control the ball, fend off opponents, and engage in various game-related activities (Nocella et al. 2011; Fitts, 1994). Understanding the relationship between grip strength and handball performance is crucial for optimizing training programs and enhancing player capabilities.

This article delves into a theoretical exploration of the key components underpinning the female handball player model (Noakes, 2000). By investigating throwing strength and palmar dynamometry, we aim to provide valuable insights that can inform training methodologies, player selection criteria, and performance evaluation metrics (Beaulieu, 2008). As the sport of handball continues to evolve, bridging the gap between theoretical understanding and practical application is essential for nurturing successful female handball players and elevating the overall quality of the game.

HYPOTHESIS

We postulate that the elasticity of the ball used in female handball significantly influences both throwing speed and palmar strength. Specifically, we anticipate that the exercise-induced fatigue protocol will yield a reduction in palmar strength measurements, reflecting the temporary muscular fatigue resulting from the exercises. Regarding throwing speed, we hypothesize that the exercise-induced fatigue will lead to a decrease in throwing speed due to the compromised muscular strength and coordination resulting from fatigue.

MATERIALS AND METHODS

Participants

Nine female handball players, from C.S. Universitatea Cluj, each with varying levels of experience, were recruited for the study. Participants were divided into three groups, with three participants in each group. The groups were distinguished based on the type of ball used: soft, medium, and hard elasticity. Prior to participation, all participants provided informed consent, and their demographic and anthropometric information was collected.

Equipment

1. **MbientLab MetaMotionS (Accelerometer):** The MbientLab MetaMotionS accelerometer is a sophisticated wearable device designed to measure and record acceleration, motion, and orientation data. This compact and lightweight sensor is seamlessly integrated into the study to capture the nuanced movements and actions of female handball players. The accelerometer's advanced technology enables the precise quantification of throwing motions, aiding in the assessment of throwing strength and technique. Through its wireless connectivity, the MetaMotionS facilitates real-time data transmission to a connected device, allowing researchers to analyze and interpret the intricate dynamics of the players' movements during handball activities.
2. **Palmar Dynamometer:** The palmar dynamometer is an essential tool used for assessing grip strength — the force exerted by the hand's muscles while gripping an object. In this study, the palmar dynamometer is employed to measure the hand strength of female handball players. By quantifying grip strength, researchers can gain insights into the players' hand function, which directly influences their ability to control the ball, fend off opponents, and

engage in various game-related actions. The dynamometer provides accurate and standardized measurements, ensuring consistency and reliability in evaluating the players' hand strength. We used a hand-held spring activated dynamometer from Ralondbey.

3. **Rubber Balls:** Rubber balls serve as the primary projectiles in handball and are utilized for various throwing exercises and measurements. These standardized rubber balls replicate the size, weight, and texture of the balls used in official handball matches. Throughout the study, participants engage in controlled throwing exercises using the rubber balls. These exercises not only facilitate the evaluation of throwing strength but also enable researchers to analyze throwing accuracy and technique. By using standardized rubber balls, the study ensures uniformity in the testing conditions and enhances the validity of the findings. We have used standard handball balls size 3.

4. **Stopwatch:** The stopwatch is an indispensable timing device used to precisely measure the duration of various handball-related activities. Researchers employ the stopwatch to record the time taken for actions such as throwing a rubber ball, completing specific drills, and performing agility exercises. Accurate timing is crucial for assessing the speed of throws, reaction times, and overall performance. The stopwatch contributes to the collection of quantitative data, allowing researchers to analyze the temporal aspects of players' actions and correlate them with other measured parameters.

These equipment components synergistically contribute to the comprehensive examination of female handball players' capabilities. The MetaMotionS accelerometer captures nuanced movement patterns, the palmar dynamometer quantifies grip strength, rubber balls replicate game-like conditions, and the stopwatch ensures accurate timing — combined, these tools empower researchers to uncover valuable insights into the intricate dynamics of female handball performance.

Procedure

1. **Baseline Measurements:** Before engaging in any physical activities, participants' baseline grip strength was assessed using the palmar dynamometer. Each participant performed three maximum-effort grip squeezes with each hand, alternating between hands. The average grip strength for each hand was recorded.

2. **Group Allocation:** Participants were randomly assigned to one of the three groups based on the elasticity of the ball they would use: soft, medium, or hard.

3. **Pre-Exercise Accelerometer Measurements:** Participants were equipped with the MetaMotionS accelerometer, securely fastened to their throwing arm. Each participant from each group performed 7-meter throws using their designated ball elasticity. Two trials of 7-meter throws were conducted for each participant, and the accelerometer recorded the kinematic data of each throw.
4. **Exercise Protocol:** After the pre-exercise measurements, participants engaged in the palmar flexion exercise protocol using the designated ball elasticity. They completed 10 isometric repetitions of the palmar flexion exercise, gripping the ball as forcefully as possible.
5. **Post-Exercise Accelerometer Measurements:** Following the exercise protocol, participants repeated the 7-meter throws using their designated ball elasticity. Similar to the pre-exercise phase, two trials of 7-meter throws were performed for each participant, and the accelerometer captured the kinematic data of each throw.
6. **Post-Exercise Palmar Dynamometer Measurements:** Immediately after the post-exercise throws, participants' grip strength was measured once again using the palmar dynamometer. Three maximum-effort grip squeezes were performed with each hand, alternating between hands. The average grip strength for each hand was recorded.
7. **Data Analysis:** The accelerometer data from the 7-meter throws were analyzed to evaluate throwing strength, technique, and consistency within each elasticity group. Grip strength measurements before and after the exercise protocol were compared for each group to assess the impact of the exercise on participants' hand strength.

Statistical Analysis

Descriptive statistics (mean, standard deviation) were calculated for grip strength measurements and accelerometer data within each group. Paired t-tests were conducted to analyze grip strength changes before and after the exercise protocol within each group. Analysis of variance (ANOVA) was employed to assess any significant differences in accelerometer data between pre-exercise and post-exercise throwing trials within each group. All the statistical analysis has been done for a statistical significance threshold of .05 (p value).

Ethical Considerations

The study adhered to ethical guidelines and received approval from the Faculty of Physical Education and Sport, Babeş-Bolyai University. All participants provided informed consent, and their privacy and data security were ensured throughout the study.

By incorporating different ball elasticities and grouping participants accordingly, this methodology aims to explore the potential impact of ball elasticity on grip strength, throwing dynamics, and overall performance among female handball players.

RESULTS

Table 1. Paired sample t-test between initial and final measurement conditions

		Mean	N	Std. Deviation	t	df	Sig. (2-tailed)
Pair 1	ThrowSpeedMax_M2	84.67	9	6.34	.679	8	.517
	ThrowSpeedMax_M1	82.75	9	7.73			
Pair 2	ThrowSpeedMin_M2	4.98	9	1.12	-1.156	8	.281
	ThrowSpeedMin_M1	5.37	9	.95			
Pair 3	PalmStrength_M2	37.22	9	9.55	-4.163	8	.003
	PalmStrength_M1	50.22	9	16.76			

Table 2. Independent sample t-test between soft and medium ball conditions

	Group	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)
ThrowSpeedMax_M1	1	3	84.65	4.30	.514	4	.634
	2	3	82.58	5.51			
ThrowSpeedMin_M1	1	3	5.07	1.39	-.648	4	.553
	2	3	5.68	0.88			
ThrowSpeedMax_M2	1	3	87.01	2.77	.067	4	.950
	2	3	86.60	10.31			
ThrowSpeedMin_M2	1	3	5.34	1.43	-.001	4	.999
	2	3	5.34	0.84			
PalmStrength_M1	1	3	46.00	25.12	-.421	4	.695
	2	3	52.67	11.02			
PalmStrength_M2	1	3	35.00	13.23	-.149	4	.889
	2	3	36.33	8.08			

Table 3. Independent sample t-test between medium and hard ball conditions

	Group	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)
ThrowSpeedMax_M1	2	3	82.58	5.51	.187	4	.861
	3	3	81.02	13.42			
ThrowSpeedMin_M1	2	3	5.68	0.88	.463	4	.667
	3	3	5.36	0.81			
ThrowSpeedMax_M2	2	3	86.60	10.31	1.015	4	.368
	3	3	80.40	2.35			
ThrowSpeedMin_M2	2	3	5.34	0.84	1.352	4	.248
	3	3	4.27	1.07			
PalmStrength_M1	2	3	52.67	11.02	.054	4	.959
	3	3	52.00	18.19			
PalmStrength_M2	2	3	36.33	8.08	-.537	4	.620
	3	3	40.33	10.07			

Table 4. Independent sample t-test between soft and hard ball conditions

	Group	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)
ThrowSpeedMax_M1	1	3	84.65	4.30	.447	4	.678
	3	3	81.02	13.42			
ThrowSpeedMin_M1	1	3	5.07	1.39	-.318	4	.766
	3	3	5.36	0.81			
ThrowSpeedMax_M2	1	3	87.01	2.77	3.150	4	.035
	3	3	80.40	2.35			
ThrowSpeedMin_M2	1	3	5.34	1.43	1.030	4	.361
	3	3	4.27	1.07			
PalmStrength_M1	1	3	46.00	25.12	-.335	4	.754
	3	3	52.00	18.19			
PalmStrength_M2	1	3	35.00	13.23	-.556	4	.608
	3	3	40,33	10,07			

DISCUSSION

This study investigated the influence of ball elasticity on throwing speed and palmar strength in female handball players, offering insights into performance parameters under varying conditions. The results contribute to understanding the interplay between equipment characteristics, athletic performance, and fatigue, providing a foundation for further investigation.

The analysis of throwing speed, encompassing both maximum and minimum values, revealed no statistically significant differences between pre-exercise (M1) and post-exercise (M2) measurements (e.g., for ThrowSpeedMax: M1 Mean = 82.75, SD = 7.73; M2 Mean = 84.67, SD = 6.34). These results indicate that the specific exercise protocol did not adversely affect throwing speed, suggesting that well-trained athletes possess adaptations that mitigate the impact of short-term fatigue. This aligns with studies such as those by Raeder et al. (2015).

In contrast, a significant reduction in palmar strength was observed following the exercise protocol (M1 Mean = 50.22, SD = 16.76; M2 Mean = 37.22, SD = 9.55). This outcome underscores the effectiveness of the protocol in inducing muscle fatigue, particularly in the muscles responsible for grip strength. Similar findings were reported by Jöris et al. (1985) and Tuquet et al. (2020), who observed declines in grip strength following high-intensity handgrip exercises in athletes. This reduction emphasizes the importance of recovery strategies and targeted strength training to enhance grip endurance.

The study compared soft, medium, and hard ball conditions, revealing no statistically significant differences in most parameters across the groups (e.g., ThrowSpeedMax_M1; PalmarStrength_M1). These findings suggest that ball elasticity does not play a dominant role in influencing throwing speed or grip strength during standard conditions. Consistent with the work of Manchado et al. (2020), external equipment factors like ball elasticity may have a smaller effect compared to biomechanical and physiological variables intrinsic to the athlete.

Interestingly, a significant difference was observed in ThrowSpeedMax_M2 when comparing soft and hard balls (Soft Mean = 87.01, SD = 2.77; Hard Mean = 80.40, SD = 2.35). This finding suggests a nuanced interaction between ball elasticity and muscle fatigue, potentially due to differences in energy transfer and grip dynamics. It aligns with studies by Mascarin et al. (2017), which emphasize the importance of equipment properties in specific performance scenarios. The interaction between fatigue and ball characteristics warrants further exploration to determine its implications for match play and injury prevention.

These findings provide valuable insights for optimizing training and equipment in handball. Coaches should prioritize grip-specific endurance training and recovery strategies to address fatigue-related declines in performance. While ball elasticity had limited impact under standard conditions, its role in fatigue scenarios suggests that equipment design could be tailored to support athletes during extended play.

Future research should expand the sample size and investigate the biomechanical and neuromuscular mechanisms underlying these interactions. Incorporating advanced technologies such as motion capture and electromyography could provide a deeper understanding of how ball elasticity influences performance. Additionally, longitudinal studies could explore the long-term effects of training with different ball types on athlete development and injury risk.

This study highlights that while ball elasticity has minimal impact on throwing speed and grip strength under standard conditions, its influence becomes significant under fatigue. These findings contribute to a nuanced understanding of performance determinants in handball and underscore the importance of integrating equipment considerations into training and competition strategies.

CONCLUSION

In conclusion, the study's results shed light on the intricate interplay between ball elasticity, throwing speed, and palmar strength among female handball players. While the exercise protocol effectively induced muscle fatigue, it did not significantly impact throwing speed. Additionally, ball elasticity exhibited minimal influence on the parameters considered, with only a subtle differentiation observed between soft and hard balls in the context of post-exercise maximal throwing speed. These findings underscore the complexity of factors influencing handball performance and advocate for continued research to comprehensively understand the multifaceted nature of player dynamics.

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