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Posted Date: 14 November 2024

doi: 10.20944/preprints202411.1051.v1

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The Effect of Fluid Restriction and Intake Conditions on the Shooting Performance of Competitive Adolescent Handball Players

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Abstract: (1) Background: This study aimed to investigate the effects of fluid restriction and intake (water vs. sports drink) on shooting accuracy and speed in adolescent handball players, a population with high sensitivity to hydration levels yet understudied in this context. (2) Methods: The study included 47 adolescent competitive handball players (15.04 ±1.5 years), and the participants were divided into low, middle, and high performance according to their shooting performance in the familiarisation session. All participants were exposed to fluid restriction, water intake, and sports drink intake conditions during handball training on different days. In all sessions, a shooting performance test was performed before and after the training session and the changes in shooting accuracy and shooting speed were evaluated. (3) Results: The training protocol resulted in a 1% body mass loss. Fluid restriction reduced shooting accuracy by an average of 88.34% and speed by 14.18% (p:<0.001, p:<0.001), while sports drink intake resulted in significant improvements of 19.68% in shooting accuracy and 3.15% in speed (p:0.009, p: 0.024). Water intake maintained baseline performance but did not lead to significant improvement (p: 0.502, p: 0.821). (4) Conclusions: Hydration level plays an important role in shooting accuracy and speed performances in adolescent handball players. Therefore, fluid intake integrated into training or match sessions may contribute to the maintenance and improvement of shooting performance.

Keywords: fluid restriction; fluid intake; shooting performance; adolescent; handball

1. Introduction

Inadequate fluid intake or fluid restriction processes lead to core temperature values rising to ~40° C in athletes [1]. Increased core temperature causes physiological stress and a gradual decrease in body water through sweating rate. Hypohydration, defined by a 1–2% decrease in body weight during exercise, is widely acknowledged as the threshold where performance impairments in coordination, cognitive function, and reaction time.[1,2]. Previous study reports indicate that adolescent athletes can only meet 2/3 of BM their fluid needs if they don't prevent their body water loss during training and competition [3]. This situation of the need to regulate fluid intake processes in adolescent athletes and to examine the effects of different fluid intake types and processes on different performance outcomes, especially under dehydration conditions. Few studies have examined fluid intake processes under exercise-associated dehydration conditions in the adolescent population.

High-intensity and intermittent sports activities, and sweat losses caused by an increased core temperature reduce body water by 1.0-1.6 L per hour (h.). These processes are most common in shooting-based sports such as handball, basketball, tennis, and cricket [4,5]. The literature, studies

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evaluating the shooting performance of adolescent athletes under hypohydration conditions showed that adolescent tennis players had decreases in service accuracy (~30%) and stroke accuracy (~69%) [6]. In another study [7], it was reported that the shooting accuracy and shooting speed of adolescent cricket players decreased in hypohydration conditions and similar hypohydration conditions negatively affected shooting accuracy in basketball players [8]. In addition, studies recommend fluid intake such as water intake, sports drink intake, etc. in terms of general health and performance decline.

Fluid intake aims to prevent the performance-impairing effects of hypohydration that occurs by administering the fluid lost during exercise with preferred beverages in specified periods and to increase performance [1,3]. In this process, water intake creates a stabilizing effect, but it is less preferred by athletes due to its tastelessness. Flavored sports drinks prepared with carbohydrates and electrolytes are preferable [1]. When the relationship between shooting accuracy and fluid intake is considered, water intake maintains the shooting accuracy and even provides low-level (3–4%) increases [9]. Sports drink contributes to performance increases by delaying physiological deterioration with carbohydrates and electrolytes in their contents [10,11]. Adolescents have larger body surface area-to-mass ratios and variable sweat rates, requiring specialised hydration approaches, especially in high-intensity sports such as handball [1] . In a small number of studies focusing on adolescent athletes; while shooting accuracy and velocity of adolescent basketball players did not change under hypohydration conditions, increased performance was observed with sports drink intake [3]. In another study, it was reported that sports drinks consumed during the training session made an indirect contribution to the increase in shooting accuracy rate at the end of training [12].

Although the number of adolescent handball players in Europe is approximately one million [13,14], the relationship between fluid intake, fluid loss, and performance in this population has been discussed to a limited extent. Especially there are no studies on the effect of fluid intake on shooting performance in adolescent handball players. For these reasons, this study aimed to investigate the effects of fluid restriction and different types of fluid intake on shooting performance and shooting speed in adolescent handball players.

Main hypotheses of this study; i) fluid restriction during training may impair shot accuracy and speed in adolescent handball players, ii) water and sports drink intake may positively affect shot accuracy and speed, iii) fluid restriction and fluid intake protocols may affect shot accuracy and speed at different levels according to shot performance level.

2. Material and Methods

2.1. Study Design

The study was conducted in four sessions (Figure 1-a) including one familiarisation session and three experimental intervention conditions. In all sessions, temperature and humidity were controlled at 28.8 ± 0.5°C and 45.5% humidity, typical of competitive indoor environments, to ensure ecological validity in simulating match conditions. BM measurements were taken at the beginning of the fluid restriction, water intake, and sports drink intake sessions. After that, a 10- min. The warm-up period and the shooting performance test were started. In this process, the participants were shooting to make 10 shots on the plate hung on the handball goal, while remaining stationary on a 7 m. handball line (Figure 1-b). Accuracy rate and speed were recorded simultaneously during the shots via the JUGS Gun. After the test, a 60-min. The Handball training program was applied to the participant group. In the water intake and sports drink intake sessions, participants were asked to consume 1% of their BM in five-minute intervals. During the water intake and sports drink intake sessions, participants were asked to consume 1% of their BM in five-minute intervals. Especially for sports drink intake, 5 min intervals were preferred in both conditions to facilitate consumption and reduce potential risks such as sudden increase in blood glucose levels [18-19]. The fluid levels that the participants should consume were determined in bottles specially labelled for them and they were warned not to exceed these levels. Immediately after the training session, BM was measured in all

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conditions and then the shooting performance test was administered again and the session ended. A rest period of at least 48 h. was given between the sessions.

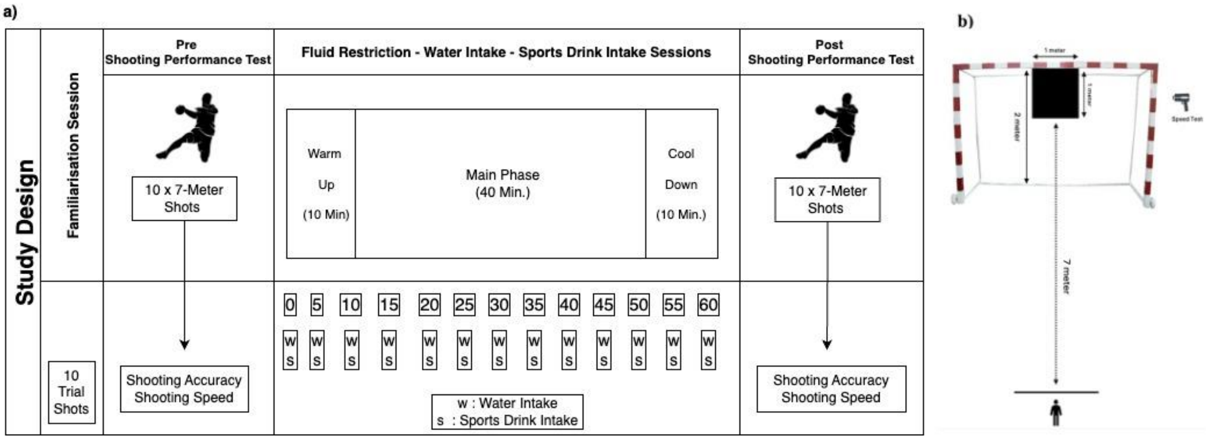

Figure 1. The design of the study (a) and shooting performance test (b).

2.2. Participants

The study included 47 healthy adolescent male handball players aged between 13 and 18 years (15.00 ± 1.49 years). The participants who engaged in handball training no less than three days a week, had an average of at least one year of training experience and had not suffered any upper extremity injuries in the earlier six months. The exclusion criteria included having an injury in the last six months [15]. G-Power 3.1.9.4 software (Germany) was used to calculate the number of participants to be included in the study and to determine the required sample size. The sample size was determined as 45 participants based on an effect size of f = 0.5, an alpha (error) rate of 5%, and a power of 95% [16-17], and 47 participants were included by anticipating potential risks. All participants and their families were informed about the study and completed the informed consent form and their voluntary participation in the study was documented. The study was approved by Manisa Celal Bayar University Health Sciences Ethics Committee with a decision dated June 7, 2020, and number 20.487.486/1870. The Declaration of Helsinki guided the conduct of this study.

2.3. Pre-Session Standardisation

Participants were subjected to fluid and food restrictions 2-h. before each session. Hydration level was monitored by subjective method and body mass change because the study contains a precise and standardised temporal transition phase between pre-shooting performance test - handball training - post-shooting performance test and the reflection of fluid intake on biomarkers (urine or blood) is time-dependent [51] and individualistic [52]. At the beginning of each session, participants' subjective hydration levels were assessed using an analogue scale asking about thirst intensity, with categories ranging from 1 ('not thirsty at all') to 3 ('extremely thirsty') [50]. Standardisation was achieved by fully hydrating before the conditions [22-23].

2.4. Familiarisation Session

In the first stage, demographic information was collected after the experimental protocol of the study was explained. Following the anthropometric measurements, the shooting performance test was explained to the participants. After the explanation, the teaching and application of the shooting performance test was carried out by making 10 trial shots to be used in the test. In this section, it was aimed to familiarise the participants with the shooting performance protocol and to reduce possible performance variability in the initial measurements.

2.5. Anthropometric Measurements

The height of the participants was measured by the same person using a tape measure, standing upright barefoot with their backs against a wall, determining the top of their heads, and recorded in centimetres. BM was measured using via Fitsense   AR 553 electronic weighing scale and recorded in kilograms (accuracy 0.1 kg) [24,27].

2.6. Measurement of Hydration Status

The BM of the participants was measured before and after the training sessions and the formula (post-BM-pre-BM / pre-BM) was used to calculate the degree of dehydration [28,29].

2.7. Shooting Performance Test

The chosen shooting performance test is widely validated in handball performance research, allowing for both inter- and intra-subject reliability due to its standardised distance and timing controls [30,33]. In the test (Figure 1b); thne participants have 10 throws from behind the 7-m. line to a 1 m. x 1 m. plastic plate hung in the middle of the handball goal. The participants performed the test with the highest speed and accuracy they could with their dominant hand. The time between the throws was set as 5 seconds for the participant to maintain attention and concentration [34]. During the throws, the speed of the handball leaving the hand and traveling to the goal was measured with a radar device branded 'Bushell Velocity Speed Gun', which can measure speeds between 10-331 km/h and has an accuracy of ±0.8 km/h [35]. The measurements obtained were recorded in km/hour [36,37].

2.9. Handball Training Programme

Participants were subjected to a 60-min. session of low and medium-intensity actions designed by an expert coach. The session included;

-Warm-up (10 min.); low to moderate running, basic passing technique drills + dynamic exercises,

-Main phase (40 min.); technical passing, positional shots, and small-sided games with positional differences,

-Cool down (10 min.); 5 min. running + 5 min. stretching exercises were carried out.

In the main phase, passing and shooting techniques and tactical variations frequently used in the match were preferred.

Water and Sports Drink Intake Process

Participants received water and sports drink supplements at 5-min intervals (1% x body mass = 12 equal parts) during handball training [3]. In the water intake condition, participants received 'Natural Water', commercial water [38]. The sodium and carbohydrate content in the sports drink was selected to both replenish electrolytes and provide an immediate energy source, as recommended in intermittent sports contexts. The sports drink intake session included 'Isotonic Sports Drink', a commercial sports drink (Powerade) that is rich in water, carbohydrates, and electrolytes. This drink contains 170 kcal/L, 39 g/L carbohydrate (sugar), 0 g fat, 0 g protein, and 1.2 g/L sodium [3,39]. The temperature of the commercial water and sports drink was 10-12°C [49].

2.10. Statistical Analysis

All statistical analyses were performed with the statistical package program JASP (version 0.16.4). The Shapiro-Wilk test was applied to determine the normal distribution of all participants' data (BM, Body Mass Index; (BMI), delta differences, loss rate; LR, shooting accuracy, and shooting speed). It was determined that the data were normally distributed. A paired sample t-test was used to evaluate the differences before and after the training. In addition, an independent t-test was used to compare different groups (body mass, BMI, delta differences, LR, shooting accuracy, and shooting speed). Using Cohen's d, determined the effect sizes between the data. The significance level was set as less than 0.05 [40].

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3. Results

3.1. Descriptive Characteristics Participants

The demographic information and shooting performance of the 47 participants can be seen in Table 1. Descriptive statistics indicated no significant differences across groups for age, training experience, height, or body mass, confirming comparable baseline characteristics.

Table 1. Descriptive characteristics about the participants.

Group	Age (years)	Training Age (year)	Height (cm)	Body Mass (kg)	BMI (kg/m²)	Shooting Accuracy (0-10)	Shooting Speed (km/h)
LP (n=13)	15±1.35	1.31±0.48	171.85±8.26	62.11±9.07	21.05±2.99	2.54±0.66	47.06±7.80
MP (n=26)	15.07±1.59	1.42±0.50	171.88±9.90	63.44±15.54	21.28±3.91	5.23±0.76	53.02±14.88
HP (n=8)	14.75±1.58	1.88±0.64	173.63±16.22	66.8±23.53	21.475±4.58	7.63±0.92	64.39±25.14
All (n=47)	15.04±1.53	1.47±0.55	172.26±10.65	63.77±15.61	21.26±3.75	5.13±0.78	51.02±11.67

Note: ALL: All Groups, LP: Low-Level Performer Group, MP: Middle-Level Performer Group, HP: High-Level Performer Group, BMI = ….

Table 2 presents the changes in the participants' hydration parameters. In the pre and post-measurement values of the fluid restriction sessions, all groups (p:<0.001, Δ:-0.64±0.32, LR-1.01%) there is a decrease. In the LP group, (p:<0.001, Δ:-0.7±0.24, LR:-1.12%) has a change. MP (p:0.65, Δ:-0.13±0.56, LR:-0.71%), but it was not statistically changed. In the HP group, (p:0.005, Δ:-0.69±0.47, LR:-1.03%) there is decrease.

Table 2. The hydration level changes of the participant.

Group		Fluid Restriction (-%1) BM Pre-Post (kg)	p	Δ	Loss Rate (%)		Water Intake (%1) BM Pre-Post (kg)	p	Δ	Loss Rate (%)		Sports Drink Intake (%1) BM Pre-Post (kg)	p	Δ	Loss Rate (%)
LP (n=13)	Pre	62.10 ± 9.07	<0.001***	-0.7 ± 0.24	-1.12	Pre	62.15 ± 9.05	0.003**	-0.19 ± 0.18	-0,30	Pre	62.34 ± 9.25	0.031*	-0.32 ± 0.48	-0.51
	Post	61.40 ± 8.95				Post	61.96 ± 8.99				Post	62.023± 9.23			
MP (n=26)	Pre	63.43 ± 15.53	0.65	-0.13 ± 0.56	-0,20	Pre	63.52 ± 15.47	0.011**	-0.22 ± 0.41	-0,34	Pre	63.82 ± 15.82	0.014*	-0.32 ± 0.63	-0,50
	Post	62.06 ± 15.15				Post	63.30 ± 15.48				Post	63.50 ± 15.64			

HP (n=8)	Pre	66.80 ± 23.52	0.005*	-0.69 ± 0.47	-1.03	Pre	66.45 ± 23.13	0.23*	-0.34 ± 0.33	-0,51	Pre	66.68 ± 23.38	<0.001***	-0.39 ± 0.16	-0,58
	Post	66.11 ± 23.20				Post	66.12 ± 23.19				Post	66.30 ± 23.37			
All (n=47)	Pre	63.22 ± 15.36	<0.001***	-0.64 ± 0.32	-1,01	Pre	63.64 ± 15.32	<0.001***	-0.23 ± 0.34	-0,36	Pre	63.90 ± 15.61	<0.001***	-0.33 ± 0.53	-0,51
	Post	62.58 ± 15.17				Post	63.41 ± 15.33				Post	63.57 ± 15.50			

Note: ALL: BM: Body Mass, All Groups, LP: Low-Level Performer Group, MP: Middle-Level Performer Group, HP: High-Level Performer Group, Δ: Post-Pre Delta Differences, p: Statistical Differences.

3.2. Hydration Levels

At the pre and post-measurement values of the Water Intake session, all groups (p:<0.001, Δ:-0.23±0.34, LR:-0.36%) there is a statistical decrease. In the LP group, (p:0.003, Δ:-0.19±0.18, LR:-0.30%) has a significant change. MP (p: 0.011,Δ:-0.22±0.42, LR:-0.34%) there is a decrease. In the HP group, (p:0.023, Δ:-0.34±0.33, LR:-0.51%) there is a statistical change.

Pre and post-measurement results regarding the sessions of Sports Drink Intake, in all groups (p:<0.001, Δ:-0.33±0.53, LR:-0.51%) there is a decrease. In the LP group, (p:0.031, Δ:-0.32±0.48, LR:-0.51%) has a change. MP (Δ:-0.32±0.63, LR: -0.50%) decline is statistically. In the HP group, (p:0.001, Δ:-0.39±0.16, LR -0.58%) there is a decrease.

The changes for shooting accuracy parameters of the participants are given in Table 3. In the Fluid restriction session, in pre and post-measurement values, all groups (p:<0.001, Cohen's:2.194) there is a decrease. In the LP group, (p:<0.001 Cohen's:2.532) there is a decline. MP (p:<0.001 Cohen's:4.471), not decline. In the HP group (p:<0.001 Cohen's:6.548) there is a decrease.

Table 3. The shooting accuracy changes of the participant.

Group	**Fluid Restriction (-%1) Shooting Accuracy Pre-Post (0-10)**		**p**	**Cohen's d**	**Water Intake (%1) Shooting Accuracy Pre-Post (0-10)**		**p**	**Cohen's d**	**Sports Drink Intake (%1) Shooting Accuracy Pre-Post (0-10)**		**p**	**Cohen's d**
LP (n=13)	Pre	2.53 ± 0.66	< 0.001***	2.532	Pre	4.59 ± 1.82	0.918	-0.029	Pre	3.38 ± 1.85	0.766	0.297
	Post	0.61 ±			Post	4.80 ±			Post	3.53 ±		

		0.50				2.00				1.50		
MP (n=26)	Pre	5.23 ± 0.76	< 0.001***	4.471	Pre	3.92 ± 1.32	0.057	-0.391	Pre	4.65 ± 1.54	0.045*	0.283
	Post	0.53 ± 0.50			Post	4.00 ± 2.16			Post	5.65 ± 1.91		
HP (n=8)	Pre	7.62 ± 0.91	< 0.001***	6.548	Pre	4.42 ± 1.92	0.004**	1.501	Pre	5.37 ± 2.13	0.042*	0.388
	Post	0.62 ± 0.51			Post	5.19 ± 2.04			Post	7.00 ± 1.77		
All (n=47)	Pre	4.89 ± 1.86	<0 .001***	2.194	Pre	4.59 ± 1.82	0.502	-0.099	Pre	4.42 ± 1.83	0.009**	0.167
	Post	0.57 ± 0.5			Post	4.80 ± 2.00			Post	5.29 ± 2.12		

Note: ALL: All Groups, LP: Low-Level Performer Group, MP: Middle-Level Performer Group, HP: High-Level Performer Group, Δ: Post-Pre Delta-Differences, p: Statistical Differences, Cohen's d: Effect Size.

3.3. Shooting Accuracy Test

For the Water Intake session, in pre and post-measurements, all groups (p:0.502, Cohen's:-0.099) there is a numerical increase. In the LP group, (p:0.057, Cohen's:-0.391) there non-increase. MP (p:<0.001 Cohen's:4.471). The HP group, (p:0.004, Cohen's:6.548) there is an increase.

The pre and post-measurement values of the Sport Drink Intake session, all groups (p:0.09, Cohen's:0.167), there is an increase. In the LP group, (p:0.766, Cohen's:0.297) there is a non-statistical increase. MP (p:0.045, Cohen's:4.471) was a decrease. In the HP group, (p:0.009, Cohen's:0.388) there is an increase (Figure 2-a.).

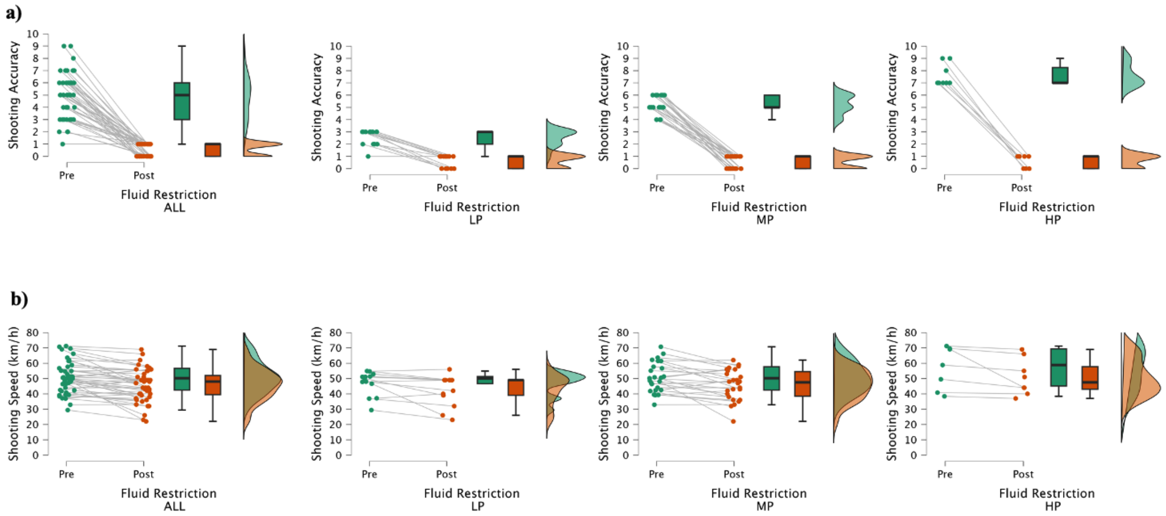

Figure 2. Fluid restriction status shooting accuracy (a) and shooting speed (b) changes of the groups.

The change in the shooting speed parameters of the participants is given in Table 4. In the Fluid restriction session, the pre and post-measurements of all groups (p:<0.001, Cohen's:0.551) there is a decrease. In the LP group, (p:0.019 Cohen's:0.754) there is a decrease. MP (p:0.009 Cohen's:0.557) were a reduction. In the HP group, (p:0.076 Cohen's: 0.073) there is a decrease.

Table 4. The shooting speed changes of the participant.

Group	**Fluid Restriction (-%1) Shooting Speed Pre-Post (km/h)**		**p**	**Cohen's d**	**Water Intake (%1) Shooting Speed Pre-Post (km/h)**		**p**	**Cohen's d**	**Sports Drink Intake (%1) Shooting Speed Pre-Post (km/h)**		**p**	**Cohen's d**
LP (n=13)	Pre	47.06 ± 7.79	0.019*	0.754	Pre	45.93 ± 8.78	0.191	0.384	Pre	43.25 ± 6.55	0.075	-0.540
	Post	43.46 ± 10.07			Post	45.19 ± 7.95			Post	45.01 ± 7.26		
MP	Pre	53.01 ±		0.557	Pre	47.81 ± 8.87			Pre	46.06 ±		

(n=26)		14.87	0.009**				0.851	0.037		6.64	0.023*	-0.477
	Post	45.84 ± 9.94			Post	47.68 ± 7.64			Post	48.11 ± 8.66		
HP (n=8)	Pre	60.47 ± 50.75	0.076	0.073	Pre	52.25 ± 12.48	0.277	-0.417	Pre	52.12 ± 9.84	0.630	0.178
	Post	45.93 ± 45.19			Post	53.30 ± 11.30			Post	51.17 ± 9.61		
All (n=47)	Pre	53.30 ± 16.27	<0.001***	0.551	Pre	48.05 ± 9.54	0.821	0.033	Pre	46.32 ± 7.64	0.024*	-0.340
	Post	45.74 ± 10.43			Post	47.95 ± 8.15			Post	47.78 ± 8.53		

Note: ALL: All Groups, LP: Low-Level Performer Group, MP: Middle-Level Performer Group, HP: High-Level Performer Group, Δ: Post-Pre Delta-Differences, p: Statistical Differences, Cohen's d: Effect Size.

3.4. Shooting Speed Test

Throughout the Water Intake session, pre and post-measurement values, all groups (p:0.821, Cohen's:0.033) there was a numerical decrease. In the LP group, (p:0.191, Cohen's:0.384) there is a non-significant decrease. MP (p:0.851, Cohen's:0.037), were non-statistically decreased. In the HP group, (p:0.004, Cohen's:6.548) there is an increase.

The pre and post-measurement values of the Sports Drink Intake session, all groups (p:3.53±1.50, p: 0.024, Cohen's:-0.340) there is an increase. In the LP group, (p:0.075, Cohen's:0.540) there is a numerical increase. MP (p:0.023 Cohen's:0.477) was an increase. In the HP group, (p:0.630, Cohen's:0.178) there is a numerical increase (Figure 2-b.).

4. Discussion

This study aimed to investigate the changes in shooting performance and speed of adolescent handball players under fluid restriction and different fluid intake conditions. The main findings of the study were i) fluid restriction during 60-min. of handball training negatively affected shooting accuracy and speed in all adolescent handball players associated with hypohydration (1%), ii) water

 doi:10.20944/preprints202411.1051.v1

intake protected shooting accuracy and speed performance, and iii) sports drink intake improved shooting accuracy and speed performance.

Fluid restriction had a negative effect on the post-session performance of all participants in shooting accuracy (p:<0.001) and shooting speed (p:<0.001). When the shooting accuracy values were declining in terms of the groups, it was seen that it was affected at the level of HP (p:<0.001), MP (p:<0.001), and LP (p:<0.001), respectively. In shooting speed values, LP (p:0.019), MP (p:0.009), and HP (p:0.076) were found to be affected. In a study conducted on sub-elite male basketball players, shooting accuracy levels were evaluated under fluid restriction and water intake conditions during 40-min. moderate-intensity training period, no difference in shooting performance was observed between conditions [5]. Devlin et al. In sub-elite cricketers evaluated shooting performance under fluid restriction and fluid intake conditions induced by ~1-h. intermittent exercise. As a result, they reported gradual deterioration in shooting accuracy in the fluid restriction condition [41]. Baker et al., sub-elite basketball players investigated the effects of fluid restriction on shooting performance in basketball. In the study, the athletes performed 3-h. intermittent walking exercise on a treadmill followed by free shootings from the foul line. As a result of the study, they found that the participants's shooting accuracy rate deteriorated under the hypohydration condition [42]. The results of our study coincide with the information reported in the literature regarding adult athletes. In particular, the process we proceeded in common with the studies is that fluid restriction has a detrimental effect on shooting accuracy and speed. This suggests that the participants experienced additional stress due to fluid restriction in addition to the stress they were already experiencing due to exercise. In addition, adolescent athletes are known to excessively breathe and sweat due to their metabolic levels. This may affect the rate of fluid loss more negatively. Therefore, the handball training caused 1% hypohydration in all participants. Hypohydration is known to cause cognitive and motor coordination problems. Shooting accuracy and speed are closely related to cognitive and motor characteristics such as reaction time, visuomotor tracking, timing, and intermuscular coordination [43]. Hypohydration has been shown to impair neuromuscular coordination, which is integral to accuracy in shooting sports, especially under the cognitive load imposed by the fast-paced demands of handball [48]. In our study, hypohydration may have affected the shooting performance of adolescent athletes with little training experience by impairing the communication between the parts. Repeated shots in the throwing test protocol also revealed more clearly the potential for low conditioned adolescent handball players to be affected by the restriction (LP shooting speed p:0.075). With this information, it was thought that higher-order associations could explain the effects of this impairment.

The current study revealed that there was no decline in shooting accuracy (p:0.502) and shooting speed performance (p:0.821) among all participants at the water intake session. Furthermore, the shooting accuracy rate considerably improved in the HP group (p:0.004). Upon analysing the shooting accuracy values of the other groups, it was determined that the MP group had p:0.918 and Cohen's value of -0.391. The LP group had a p:0.057 and a Cohen's value of -0.029. The HP group had a Cohen's value of -0.417. The LP group had a Cohen's value of 0.384. The MP group had a Cohen's value of 0.037. When the literature was examined, it was reported that water intake (as much as the BM lost) after each period of a 40-min. low-intensity basketball competition with national-level female basketball players improved the number of shootings by 5.3±2.8% and the overall shooting accuracy rate by 30-35%[44]. In the Burke et al. study, a 2-h. simulated tennis competition was performed with tennis athletes. During the experiment, one group had a regular water intake of 505 millilitres. while the other group was subjected to fluid restriction. After the competition, a shooting performance test consisting of 50 shots was applied. As a result, the hit rate in the water intake condition was 49.45%, while the rate in the fluid restriction condition was 48.65% [9,45]. In adolescent athletes, electrolyte losses, especially sodium, occur at a high sweating rate independent of environmental conditions (temperature, humidity). The potential of these losses to decrease performance is known [46]. In the handball training protocol applied in our study, intermittent water intake equal to BM loss protected shooting performance. The significant improvement in the HP group and the preserved performance in the other groups suggest that in this training protocol,

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shooting performance parameters are less affected by water intake, possibly slowing the deterioration of fluid-electrolyte balance.

The current study showed that both shooting accuracy (p:0.09) and shooting velocity (p:0.024) increased in all participants during the sports drink session. In the intergroup evaluation, it was found that the HP (p:0.042) and MP (p:0.045) groups improved, while the performance was maintained in the LP group and there was no significant change. In the shooting speed values, it was concluded that there was a significant improvement in the MP group (p:0.23), while no significant change occurred in the LP (p:0.075) and HP (p:0.630) groups. In the literature related to adolescent and late adolescent athletes; Carvalho et al. examined the effects of 90-min. training sessions performed under conditions of fluid loss, water intake (3.8 mg/L sodium), and sports drink (7.2% sugar, 0.8% maltodextrin, and 510 mg/L sodium) intake on a basketball shooting (2 and 3-point shootings and free shooting) performance [3]. As a result of the study, it was reported that 2-point (55.0 ± 20.2%), 3-point (36.7 ± 19.7%), and free shooting (59.2 ± 22.8%) performances of adolescent basketball players(14.8 ± 0.45 years) were impaired in the fluid restriction condition. In the water intake condition, improvements were observed in 2-point (60.8 ± 12.4%), 3-point (37.5 ± 16.0%) and free shooting (62.5 ± 20.1%) values. However, the highest improvement in 2-point (60.0 ± 16.5 %), 3-point (42.5 ± 16.0 %) and free shooting (65.8 ± 20.2 %) values was obtained in the sports drink intake condition [47]. In the other study, adolescent basketball players were subjected to a fluid restriction condition and given a sports drink with 6% carbohydrate content in the other condition during a 2-hour intermittent exercise session. As a result, while the free shooting accuracy percentage was 60±8% in the sports drink intake condition, this rate decreased to 45±9% in the fluid restriction condition. Baker et al. performed a 3-h. intermittent treadmill exercise in sub-elite basketball players (17±28 years) under fluid restriction and sports drink (0% carbohydrate and 18% sodium) intake conditions. Free shooting performance was evaluated immediately after the exercise [44]. As a result of the study, while the hit rate was 86±6% in the sports drink intake condition, this rate was found to be 83±3% in the fluid restriction condition. Considering the information presented, it is seen that the positive results we obtained are highly compatible with the literature.

The best of our knowledge, this is the first study specific to adolescent handball athletes conducted with this research design. The carbohydrates and electrolytes in the sports drink may have a positive effect on handball shooting accuracy and shooting speed by improving the mechanisms related to cognitive and motor coordination, thus indirectly increasing shooting performance. Sports drink supplementation in an intermittent model in adolescent handball players has a high potential to positively affect shooting performance parameters.

5. Limitation

Performance fluctuations in shooting accuracy and speed values occurred in all sessions of the participants. Previous research has shown that fluctuations in accuracy and speed values in handball shooting performance are affected by training experience [34]. The fact that possible accuracy decreases that may occur due to the increase in shooting speed was not observed in our study eliminates the possibility that speed fluctuations are caused by focusing on accuracy. On the other hand, the subjective hydration questionnaire we used in this study, although practical, may be prone to bias and lacks specificity. Future studies may consider including measures of urine osmolality or specific gravity to objectively monitor hydration status. Discuss possible confounding variables such as individual variability in sweat rates or previous hydration levels: Uncontrolled variables such as individual sweat rates and previous hydration status may introduce variability in results. A standardised pre-test hydration protocol or individual sweat rate monitoring may reduce these factors in future research. Finally, since our research was conducted in a controlled indoor environment, the findings may not be fully generalised to outdoor conditions where temperature and humidity are variable.

6. Conclusions

The findings of the study show that hypohydration of 1% negatively affects shooting performance in adolescent handball players, while intermittent water intake in the amount they lose protects performance. On the other hand, it was found that performance increased with commercial sports drink intake. It was also observed that this benefit obtained from water and sports drink intake was different according to the shooting performance level (HP vs LP) of adolescent handball players. Therefore, these findings revealed that hydration is a key factor in the shooting performance of adolescent handball players.

Based on the findings, adolescent handball players should be encouraged to consume small amounts of sports drinks during training and matches, especially during high-intensity periods, to maintain shooting performance. It is also recommended that handball field practitioners, nutritionists, coaches and athletes utilise the fluid intake protocols implemented in this study to maintain and improve shooting performance.

Author Contributions: EU: EG designed this study . EU, EM, EG researched data. EU, EM analysed the data. EU,EM,EG, NRS and CSB interpreted the results and drafted the manuscript. CSB, EG supervised the study. All authors contributed to the review and revision of the manuscript and agree to be accountable for all aspects of work ensuring integrity and accuracy.

Funding: Not applicable.

Ethics approval and consent to participate: The study was performed according to the guidelines of the Helsinki Declaration and was approved by the Ethics Committee of Manisa Celal Bayar University Health Sciences (Approval Date/Number: 2020–07/20.487.486/187). All participants were agreed to take part in the study and provided informed written consent.

Consent for publication: Not applicable.

Data availability: All collected data in the current study are available after the permission of the whole writer. Written proposals can be addressed to the corresponding authors for appropriateness of use.

Acknowledgments: Not applicable.

Competing interests: The authors declare no competing interests.

Abbreviations

BMI	Body Mass Index
BM	Body Mass
Min.	Minute
H	Hours
%	Rate

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