Published in the Russian Federation
European Journal of Physical Education and Sport
Has been issued since 2013.
ISSN: 2310-0133
E-ISSN: 2310-3434
Vol. 10, Is. 4, pp. 197-205, 2015

DOI: 10.13187/ejpe.2015.10.197
www.ejournal7.com

Kinematic Analysis of the Effect of Rapid Weight Loss by Sauna on Elite Wrestlers' Single Leg Takedown Technique

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Abstract

Rapid weight loss and weight cutting are two widely used methods to reach competition weight; Sauna and dehydration as well as sweating through physical activity are very common. Many athletes with specific weight classifications such as wrestling, judo, and weight lifting want to participate in competitions 6-8 % below their normal weight. The aim of this study was to present an example of the quantitative contribution of modern sport biomechanics. The results showed that rapid weight loss could affect elite wrestlers 'performance techniques. These tests were performed in three, phases: pre-test (without dehydration), post-test1 (dehydration 3.5 %), and post-test2 (18 hours after rehydration). Thirteen experienced and elite wrestlers who had been training for 8 years participated as subjects (age 18.38 ±1.32yrs, height 1.70±0.04 m; body mass 71/111±11.80 kg). Reflective body markers attached all of the subjects' joints, and they performed single-leg takedown in front of three cameras (hero 3 @15fps/1440 p). 3D motion analyses method measured linear and angular kinematic characteristics were evaluated by Skillspector (1.3.2 version) software. Statistical analysis via the parametric and non-parametric Wilcoxon Rank-sum test and Repeated Measure test showed significant differences between the single-leg takedown techniques. The finding demonstrated negative effects on shoulders, pelvises, and knees linear max velocity, position, and angular max velocity.

Keywords: dehydration, 3D video analysis, velocity, position, angular velocity.

Introduction

Wrestling is one of the Olympic sports and is popular around the world. So far, very little research has been done on the characteristics of the biomechanics of this sport. Biomechanics is the science that studies the structure and function of biological systems using laws and methods of mechanics, and the result of this science can be great help for athletes and coaches. Athletes have weight loss with different purposes such as participation in a lower weight class, achieving a state of perfect physical fitness, or increasing the level of sports performance. wrestling involve activities such as pulling, pushing, squatting, squeezing, and twisting, and single-leg takedown technique is one of them. However, there is lack of scientific literature that examines the kinematic motions of the wrestling techniques bilaterally (Evans, 2013; wang G, liou H, 2011).

Wrestlers practice these weight loss techniques believing their chances of competitive success will increase; ironically; weight cutting may impair performance and endanger the wrestler's health. There are some facts indicating that the performance of complex tasks, such as those involved in many teams, is also ruined at dependently low levels of fluid shortage. Most of the researches have shown impaired dehydration power, strength, balance (static and dynamic), endurance, and vital functions (Brausch, 2011; Lambert & Jones, 2010; Pettersson & Berg, 2014; Sagayama et al., 2014; Savoie, Kenefick, Ely, Cheuvront, & Goulet, 2015).

Proving the negative effects of weight cutting in the implementation techniques of sports is an important factor in athletic performance and injury prevention, especially in wrestling. By investigation, the effects of dehydration on the biomechanical parameters can be a deterrent to prevent dehydration among the wrestlers. A three-dimensional analysis has to be done for rotating or more complex movements, such as wrestling, judo, soccer, gymnastic etc. Therefore 3D motion analysis requires at least two cameras. Most movements require four or more cameras. This study used three cameras, calibration frames, and body markers to analyze single-leg takedown technique (Barbas et al., 2011; Franchini, Brito, & Artioli, 2012; Goulet, 2011; Imamura, Hreljac, Escamilla, & Edwards, 2006; Rita S, 2006).

During a match, besides the ability to act a technique such as single-leg takedown skill, dehydration may impair performance in wrestlers and defeat may be the result. By studying the kinematics of the single-leg takedown technique, as well as the differences between execution by guards and non-guards limbs, coaches and athletes will gather very useful information. The information will result in technique effectiveness in matches and a reduction of dehydration method. We can measure the joints and segments of linear kinematics such as velocity, position, acceleration before dehydration, and after rehydration and angular parameters (Imamura et al., 2006; Payton, Bartlett, & British Association of Sport and Exercise Sciences., 2007; Roger, 2007; Shan & Zhang, 2011).

Method

1. Methodology: researchers used the experimental and laboratory method by selecting two groups, sauna group, and active group.

2. The research sample:

Thirteen male elite wrestlers were recruited from YOL SPOR| gym, to participate in this study, they were in training camp. The mean age, height, and weight were 18.38 ±1.32 yrs, 1.70±0.04 m, and 71/111±11.80 kg, respectively. All participants were free of injury or illness, and they used their guard side of their body as their dominant side and the unguarded side as their non-dominant side. The experimental protocol was performed in accordance with the Declaration of Helsinki for human experimentation and was approved by the university of Ataturk ethical committee. The subjects from the gym read and signed the informed consent form.

3. Measurements

All subjects participated in a pre-test, and a first and second post-test and did a single leg takedown technique 3 times, and all of the movements were done without a competitor. Implementation of techniques is very common among wrestlers. The experimental group sat in the sauna three times for a period of 60 min. (3×20 min) and submitted their weight variations. Calibration cube, high-speed camera, and reflective markers were used for video analysis. The authors at university built calibration cube. Reflective joint markers were placed on both sides of the body at (right/left acromion, Lateral epicondyle of the humerus, wrist-ulna, ASIS, knee, ankle, toe must be parallel with heel marker). Video recording was done with high-speed digital camera hero three@15fps/1440 p; Skillspector (Version 1.3.2) software was used for 3D video analysis. Full body model with 14 points was used for calculating kinematic parameter of movements. The following measurements were taken: linear and angular kinematic (points velocity, position, angular velocity). Data smoothing was done with the help of frequency filter.

4. Procedure

Testing was carried out in the YOL SPOR gym in Turkey/Erzurum with in a 2-day period, starting at 14:00 o'clock up to20:00 under the following environmental condition: average temperature 25°C (minimum 23, maximum 27), and sauna temperature was 60-70°C. The cameras and calibration cube were fixed on the wrestling mats and were synchronized with each other. First camera was placed in front at 2.30m, and the second and third cameras were placed sideways at 3m from the calibrated place on the mat; subjects voided their bladder as completely as possible, and nude body weight and body composition were measured (Tanita, TBF-300A Body Composition analyzer, Japan, weighing accuracy of ±10g). Subjects participated in pre-test before dehydration. Weight cutting procedures were tested on three occasions: 1) before sauna, 2) after three consecutive sauna sessions (3 × 20 min at 60-70 °C, with 5 min rest interval), and 3) after 18 hours rehydration period. Rehydration period was performed according to wrestling rules, meaning that weight measuring was done one day before the matches. Rehydration period was controlled by the authors based on the amount of the use of food and water package. Wrestlers done single-leg takedown technique for three times; all movements were performed at maximum physical effort.

5. Statistical Analysis

The data are reported as mean ± standard deviation. We have measured each factor three times, so the average of this information was used as evidence. The normal distribution of data was determined by k-s test. The parametric and non-parametric tests such As Repeated Measures and Friedman were performed to compare the variables between pre-test and post-tests. The researchers in this study had an independent sauna group with three tests (pre-test, first post-test, and second post-test 18 hour after dehydration). The relationships between tests were compared by repeated measures test. Statistical analysis was performed by IBM SPSS version 21.

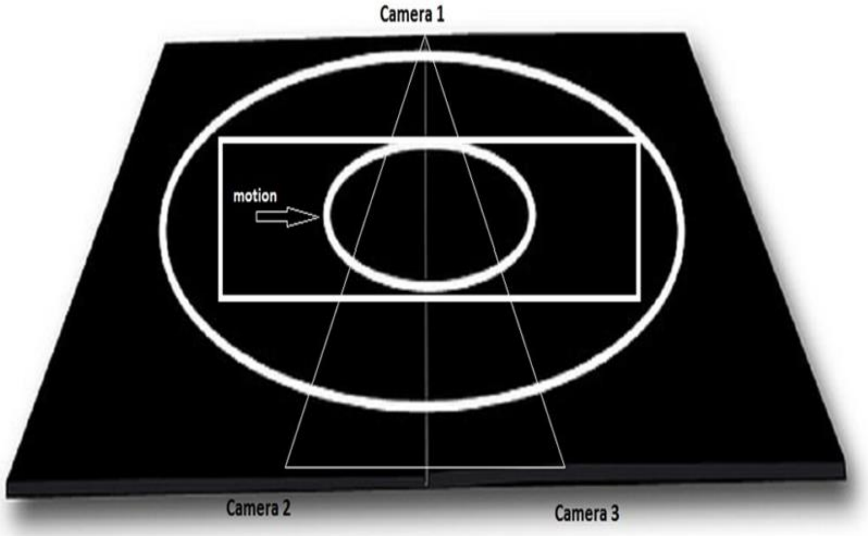

Figure 1. Shows that Position of cameras and calibration cube during tests

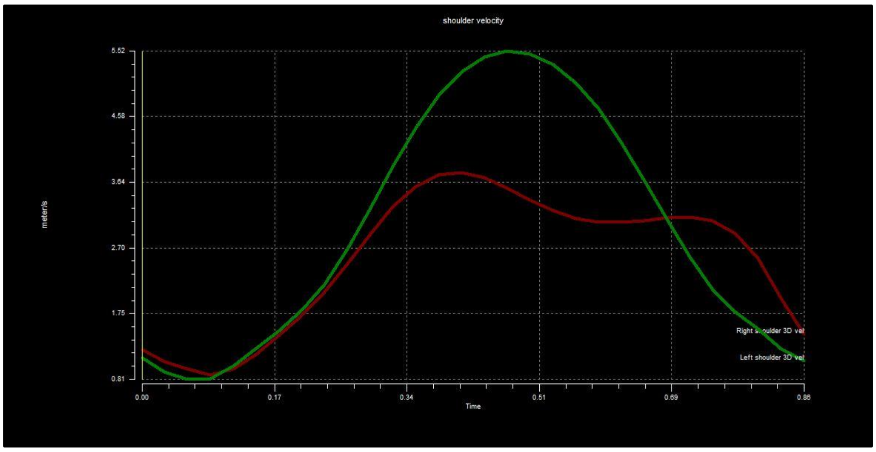

Figure 1a

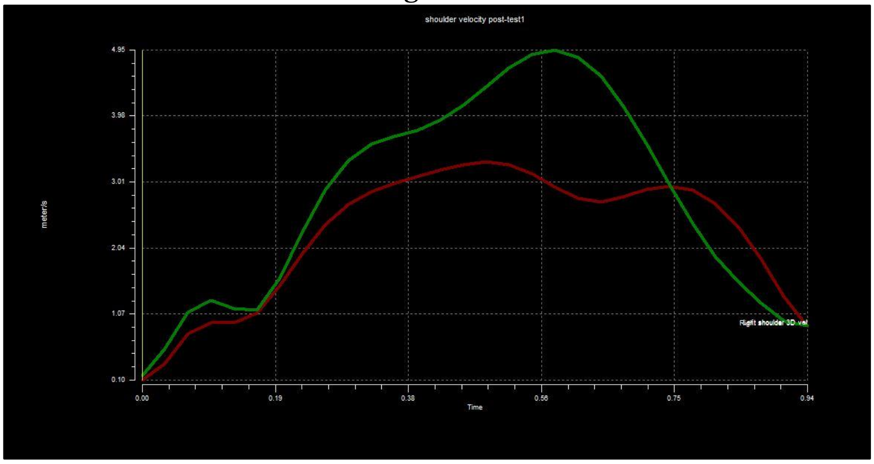

Figure 2b

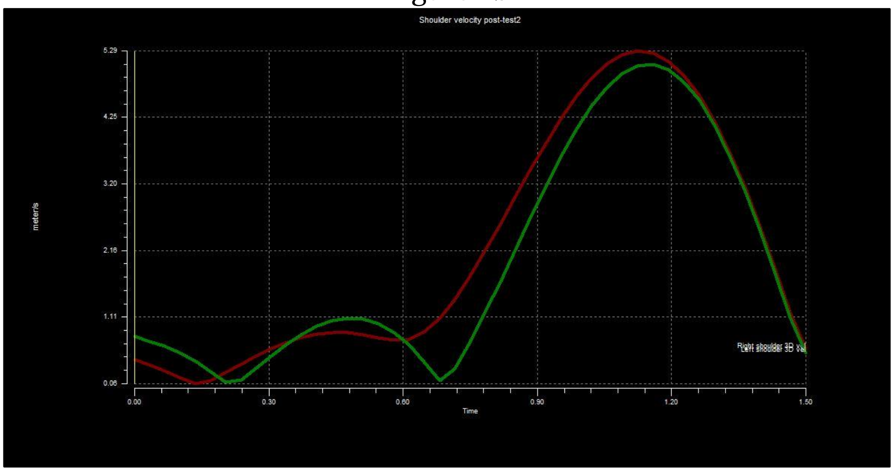

Figure 2c

Figure 2

Figure 2. shows that Variation of the shoulder linear velocity during pre-test and post-tests, (Fig.2a) Left and right shoulder velocity in pre-test, (Fig.2b) Left and right shoulder velocity in post-test1, (Fig.2c) Left and right shoulder velocity in post-test 2

Results

Body compositions were measured between tests. The body weight was 71.111±11.801 in pre-test time and 68.034±11.410 in post-test1 after dehydration and 70.205±11.902 in post-test2 after rehydration. This represented a mean dehydration of 2.84±0.34 kg. Water replacement during rehydration was 2.170±1.254 kg the results of which are given in table 1. The results of kinematic parameters, a statistical analysis of variables showed that acute dehydration impact, right and left shoulder velocity decrease significantly ($p<0.52$) ($p<0.27$), position points decreased in post-test1 and post-test2 ($p<0.001$); right and left pelvis velocity and position points decreased in post-test1 and post-test2 ($p<0.001$). Right trunk segment's angular velocity was affected in post-test1 and post-test2 ($p<0.001$); left trunks segment's angular velocity was impaired in post-test1 and post-test2 ($p<0.025$). Right knee point velocity decreased in post-tests ($p<0.006$), and left knee point velocity and right, left points position are impaired in post-tests ($p<0.001$). Right and left thigh segments decreased in post-test1 and 2 ($p<0.001$) ($p<0.004$).

Table 1: Descriptive statistics of wrestlers' body composition changes during tests

	N	Mean	Std. Deviation
Age	13	18.3846	1.325
body height m	13	1.7008	.0469
Weight pre-test (kg)	13	71.111	11.801
Weight post-test1 (kg)	13	68.034	11.410
Weight.post-test2 (kg)	13	70.205	11.902
Fat pre-test %	13	4.923	1.397
Fat post-test1 %	13	4.860	1.411
Fat.post-test2 %	13	4.815	1.352
Fat mass pre-test (kg)	13	3.384	1.215
Fat mass post-test1(kg)	13	3.324	1.201
Fat mass post-test2(kg)	13	3.312	1.255
Fat free mass pre-test (kg)	13	64.188	8.522
Fat free mass post-test1 (kg)	13	60.041	9.269
Fat free mass.post-test2 (kg)	13	60.735	9.367
Total body water pre-test (kg)	13	45.949	6.361
Total body water.post-test1 (kg)	13	43.246	5.986
Total body water.post-test2 (kg)	13	45.274	6.267

Table 2: all points and segments' repeated measure results during tests

Variables		Mean	SD	N	F	df	Sig
Right shoulder velocity (m/s)	Pre-test	4.3138	.55216	13	3.359	2	.052*
	Post-test1	4.2215	.52508	13			
	Post-test2	4.3238	.53167	13			
Left shoulder velocity (m/s)	Pre-test	4.6917	.52286	13	4.256	2	.027*
	Post-test1	4.6175	.55852	13			
	Post-test2	4.7025	.54526	13			
Right shoulder position (m)	Pre-test	2.5615	.08905	13	39.969	2	.001*
	Post-test1	2.4515	.07069	13			
	Post-test2	2.4792	.06994	13			

Left shoulder position (m)	Pre-test	2.7192	.10372	13	45.074	2	.001*
	Post-test1	2.6177	.10895	13			
	Post-test2	2.6385	.10148	13			
Right pelvis velocity (m/s)	Pre-test	5.4277	1.04917	13	14.047	2	.001*
	Post-test1	4.6038	.74185	13			
	Post-test2	4.6338	.74942	13			
Left pelvis velocity (m/s)	Pre-test	6.7362	.93830	13	92.746	2	.001*
	Post-test1	5.3023	.79955	13			
	Post-test2	5.3154	.78569	13			
Right pelvis position (m)	Pre-test	2.4446	.05364	13	56.069	2	.001*
	Post-test1	2.3738	.05752	13			
	Post-test2	2.3931	.05808	13			
Left pelvis position (m)	Pre-test	2.7177	.03395	13	26.490	2	.001*
	Post-test1	2.6431	.05298	13			
	Post-test2	2.6577	.04206	13			
Rıght trunk angular velocıty (deg/s)	Pre-test	412.2400	6.13343	13	283.289	2	.001*
	Post-test1	361.0577	11.86545	13			
	Post-test2	366.0577	13.89714	13			
Left trunk angular velocıty (deg/s)	Pre-test	440.6985	6.17422	13	4.301	2	.025*
	Post-test1	432.9600	7.98980	13			
	Post-test2	433.8692	7.81831	13			
Right knee velocity (m/s)	Pre-test	4.2231	.56587	13	6.291	2	.006*
	Post-test1	3.5754	.63478	13			
	Post-test2	3.5431	.61703	13			
Left knee velocity (m/s)	Pre-test	7.1277	.58260	13	216.069	2	.001*
	Post-test1	5.6138	.66391	13			
	Post-test2	5.7200	.69714	13			
Right knee position (m)	Pre-test	2.6977	.07704	13	32.966	2	.001*
	Post-test1	2.6023	.05215	13			
	Post-test2	2.6146	.04095	13			
Left knee posıtıon (m)	Pre-test	2.1992	.04232	13			

	Post-test1	2.1192	.04291	13	50.787	2	.001*
	Post-test2	2.1338	.04646	13			
Right thigh segment angular velocity (deg/s)	Pre-test	326.2100	7.64211	13	377.893	2	.001*
	Post-test1	276.4962	8.38864	13			
	Post-test2	282.5731	9.34569	13			
Left thigh segment angular velocity (deg/s)	Pre-test	647.3000	24.14199	13	77.343	2	.004*
	Post-test1	555.1685	35.47310	13			
	Post-test2	540.0769	17.45317	13			

Significant at $p \leq 0.005$

Discussion

There are three important biomechanical patterns to do wrestling: joints velocity, joints position, and segments angular velocity. The main aim of the study was determining the effect of dehydration by passive method in the ability of wrestler in performing a technique and the effects of weight cutting on joints and body biomechanical patterns. Literature on the effects of dehydration and rehydration on the biomechanical parameters does not exist. Therefore, this is the first study to investigate the effects of dehydration on biomechanical parameters, and this is the first on the biomechanical patterns among the wrestlers(WANG G et al., 2011).

The results show that the biomechanical segments and points studied in this research , due to the rapid weight loss, had a sharp decline in both sides of wrestlers' body ($p<0.001$); data showed linear velocity in shoulder, pelvis and knee decreases strongly ($p<0.001$). These results were in accordance with those of Evans and Paterson (Pettersson & Berg, 2014).

This difference of joints' linear velocity and position in dehydration and rehydration times could be explained by the short time motion tests, mean, and peak power. Time is the most important component of power, so we could say if the short time motion such as performing a technique decreases in a special condition, power, strength and muscle performance will decrease too. There are many studies showing that most patterns of physical fitness are affected by rapid weight loss. Isometric handgrip strength and back strength decreased, and muscle performance, especially dynamic postural control, changed after weight cutting. Wingate performance and mean jump height showed similar decline after fluid restriction between the post-tests (B, DM, J, & JR, 2004; Brausch, 2011; Murray, 2007).

The results of the power data as the most commonly used scale to measure performance are closely related with motion biomechanics, and many studies have used power data to determine the effects of acute dehydration on athletic performance. Mean power, peak power, max anaerobic power, and total power in upper and lower body show significant decrease in some studies after weight cutting (Kraft et al, 2012; Hayes and Morse, 2010). Our results aligned with the results of these studies, mean left and right shoulder velocity ($p<0.001$), right and left pelvis ($p<0.001$), right and left knee velocity ($p<0.006$, $p<0.001$) significantly decrease in post-test1 and post-test2. These results showed the wrestlers' technique performance was slower in post-test1 and post-test2 than pre-test.

Most studies showed the deficit effect of dehydration on anaerobic performance than aerobic performance. Wrestling is an anaerobic sport, and all techniques have to be done in short time rapidly; power, speed, balance, coordination, and strength are the main components to the implementation of techniques in wrestling and other atrial sports. The negative effect in biomechanical parameters can be discussed by anaerobic performance component. So decrease in reaction time and central reaction time in martial arts showed biomechanical parameters decreased by dehydration, and our study confirmed the results of the study by (Evans, 2013; Jones, Cleary, Lopez, Zuri, & Lopez, 2008; Lambert & Jones, 2010; Maughan & Shirreffs, 2010).

Our finding suggests that18 hour's rehydration time was not enough to recover performance. Mean linear velocity, position, and angular velocity in post-test2 decreased compared with pre-test. Rehydration period for 24 hours is not enough to recovery and performance before weight cutting function, central reaction time, and muscular power (Franchini et al., 2012; Kordi, Ziaee, Rostami, & Wallace, 2011). Dehydration by 5% of body weight strongly reduced the repetitions during strength training period, and our study with 3.5-4% dehydration amounts showed biomechanical defected. Hypohydration impaired overall muscle endurance in upper and lower body; anaerobic power altered with Hypohydration, but anaerobic capacity and vertical jumping ability did not (Jones et al., 2008; Savoie et al., 2015; V, P, J, M, & E, 2007).

Overall, the findings of this study indicate that dehydration through saunas has negative effect on the biomechanical parameters, linear velocity and angular velocity, and position of shoulders, hips, and knees joints in wrestlers during a single takedown technique will drop. Therefore, it is recommended to athletes and coaches to avoid weight cutting specially using a sauna.

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