



## The Effect of Training Experience on Postural Control in Competitive Wrestlers

by

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*The aim of this study was to evaluate the effects of training experience in wrestling on postural control. Fourteen elite athletes with at least 8 years of wrestling training and competition experience participated in the study. The control group consisted of fifteen healthy adults who were not competitive athletes. The center of pressure (COP) trajectories were recorded with the use of an AMTI force plate at a sampling frequency of 50 Hz. The rambling-trembling decomposition method was used to analyze the COP trajectory data. The main finding was a significant effect of training experience on postural control in only the sagittal plane. Interestingly, significant differences in velocity were observed for the trembling component of the COP. All described variables were significantly higher in wrestlers. We hypothesized that balance training may lead to task-specific neural adaptations at the spinal and supraspinal levels. It was concluded that further research of high methodological quality is needed to determine the effect of training experience on balance control in elite athletes. Additionally, this effect should be observed in youth athletes, as it may be treated as a selection criteria in the training process.*

**Key words:** balance, motor abilities, rambling/trembling analysis, combat sports, training experience.

### Introduction

Balance is of primary importance in life. Maintenance of the body's center of gravity vertically over the base of support is crucial not only for stability, but also for moving and performing voluntary movements (Massion, 1992). Although postural stability has been extensively studied in different groups of subjects for decades, there is still much unknown in the area of the postural control processes.

Numerous studies have investigated posture control in elite athletes. Within the field of sport performance, investigators have generally focused on four aspects of posture (for review see Hrysomallis, 2011). First, most of the current research concentrates on comparisons of balance in athletes from different sport disciplines. The second important aspect of balance research in sports has aimed to determine differences in

balance of athletes at different sports level within the same discipline. The third area is dedicated to evaluation of the relationship between balance and performance measures. Finally, experiments have focused on examining the influence of balance training on sport performance and technical skills (Hrysomallis, 2011). Additionally, balance has also been analyzed in the context of injury risk (Meeuwisse et al., 2007; Fulton et al., 2014; Gabbet, 2016).

When examining static balance in the context of sport performance, researchers have used different field tests that are usually performed in a bipedal or unipedal stance, on stable or unstable surfaces, and with eyes open or closed (Kioumourtzoglou et al., 1997; Pillard and Noe, 2006). The most prevalent laboratory tests for evaluation of static balance involve monitoring

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the center of pressure (COP) migration with the use of force platforms (Pillard et al., 2002; Asseman et al., 2008).

Unfortunately, ambiguous interpretation of COP displacement raises many discussions and discord between scientists. For example, it is agreed that in shooting or archery performance, smaller body sway is more desired. However, there is no such agreement in combat sports, where increased sway might be observed. Adaptations might be the effect of the nature of movement and routine of performance cause specific adaptations in posture control. Comparing kata and kumite practice in karate or figure skating against hockey could serve as a perfect example. The lack of consensus indicates that more research is required to understand the effect of expertise and the influence of balance training on technical skills in athletes representing different sport disciplines. This fact supports the aim of our study.

We aimed to evaluate the effects of training experience on postural control. Competitive wrestlers should have a high level of ability to maintain a favorable position during the fight, which has dynamic characteristics and involves optimal control of balance. Thus, we hypothesized that these athletes have a greater postural sway and a more irregular signal in relation to untrained subjects. The rambling-trembling decomposition method proposed by Duarte and Zatsiorsky (1999) was used to analyze COP trajectory. This method has not been commonly used in data analysis of sport postural stability studies.

## Methods

### *Participants*

Fourteen competitive wrestlers with at least 8 years of wrestling training and competition experience participated in the experiment. The wrestling study participants were ranked in the first 6 places of the European or World Championships. Prior to data collection, the subjects' body mass and height were recorded (mean  $\pm$  SD; mass:  $79.66 \pm 16.02$  kg; height:  $1.76 \pm 0.11$  m).

The control group consisted of fifteen young, healthy adults (PE students) that were not competitive athletes. They were selected from a group of volunteers according to similarity of

basic somatic variables (body mass:  $75.09 \pm 7.19$  kg; body height:  $1.75 \pm 0.05$  m). None of the subjects reported any balance disorders or neurological impairments in the past 2 years. All participants gave their written informed consent to participate in this study, which was approved by the local ethics committee and was in accordance with the Helsinki Declaration.

### *Stabilographic measurement*

The COP trajectories were recorded with the use of an AMTI Accugait force plate, sampling at a frequency of 50 Hz. The offline raw data were low-pass filtered at 6 Hz using a dual-pass, second-order Butterworth digital filter implemented in MATLAB (*MathWorks*). Subjects performed 3 trials of quiet standing with eyes open and eyes closed. Study participants were instructed to stand barefoot in a comfortable foot position with their arms along their sides and with their gaze focused in front of the subjects 2 m away (a round target with 2 cm diameter was marked on the wall). The duration of each trial was 30 s with a 60 s rest interval between trials during which the subjects were asked to step off the platform. The procedure was verified as reliable by Slomka et al. (2012).

First, standard posturographic variables were calculated. The following variables were further analyzed: range of displacement (ra) of the COP signal (cm), standard deviation (std) of the COP (cm), and velocity (v) of the COP (cm/s). Next, the data were further processed via stabilogram decomposition, according to the method proposed by Zatsiorsky and Duarte (1999, 2000). Two components: rambling (the motion of an instant equilibrium point with respect to which the body's equilibrium is instantly maintained) and trembling (the oscillation of COP around the reference point trajectory) were calculated.

The sequence of operations used for stabilogram decomposition is described below (Zatsiorsky and Duarte, 1999). At the instances when the horizontal force (Fhor) is zero the body is in an instantaneous equilibrium state. The instances of zero horizontal force (instant equilibrium point [IEP], i.e., the COP locations in the instances when the horizontal forces were zero) were identified in the Fhor time-history data. In the COP displacement data, the COP positions at the instants when Fhor = 0 (IEP) were located and interpolated by cubic spline functions

to obtain an estimate of the rambling trajectory. The COP trajectory was compared with the interpolated rambling trajectory. To obtain the trembling trajectory, the deviation of the COP from the rambling trajectory was determined.

All calculations for COP, rambling (RAMB) and trembling (TREMB) components were made in both the anterior-posterior (A/P) and media-lateral (M/L) directions.

#### Statistical analysis

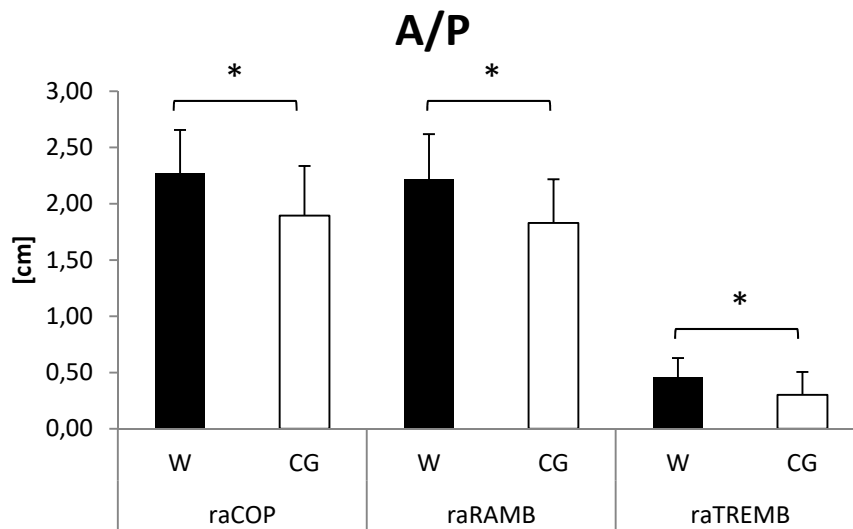
The Shapiro-Wilk and Lilliefors tests were used to check the data for normal distribution, while homogeneity of variance was investigated with the Levene's test. The significance of differences between the means of particular variables in the groups was evaluated by using one-way ANOVA. When some parameters failed to meet the assumption about the normal distribution of variables and variance

homogeneity, the Mann-Whitney U test was used. The significance level was set at  $p < 0.05$ .

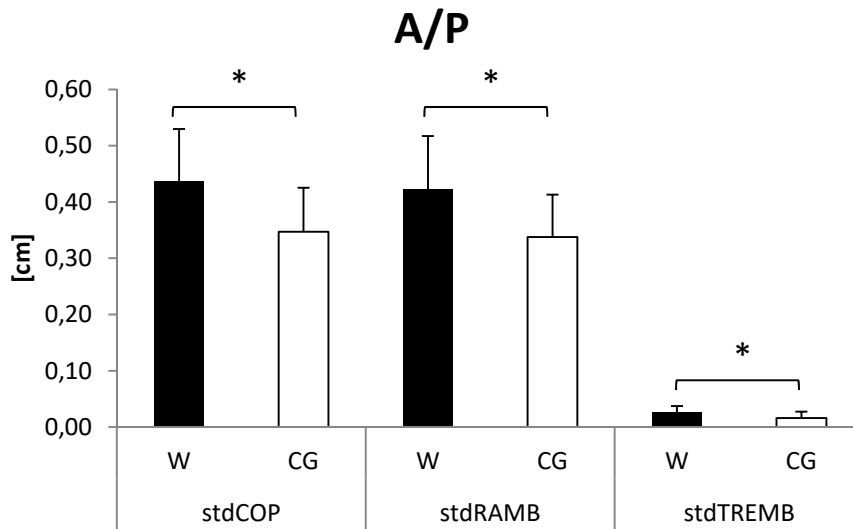
## Results

The results of a one-way ANOVA revealed a significant main effect of training experience on postural control in the sagittal plane. As shown in Table 1, in the sagittal plane, the differences in range of displacement (ra) and standard deviation (std) variables were significant for all three variables (COP, RAMB and TREMB) ( $p < 0.05$ ). However, significant differences in velocity (v) were observed only for the trembling component of the COP. Note that all described variables reached higher values in the wrestlers (W). These results are presented in Figures 1-3.

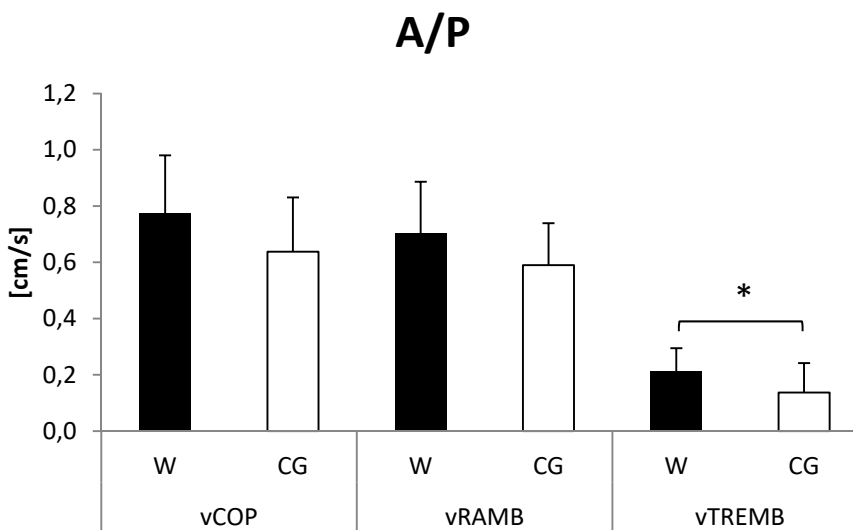
In the frontal plane, none of the variables were significantly different between groups ( $p > 0.05$ ). Details are presented in Table 2.



**Figure 1**  
Mean range of COP, rambling and trembling signal displacement in the anterior-posterior direction



**Figure 2**  
 Mean standard deviation of COP, rambling and trembling signals displacement in the anterior-posterior direction



**Figure 3**  
 Mean velocity of COP, rambling and trembling signals displacement in the anterior-posterior direction

**Table 1***Results of one-way ANOVA in the anterior – posterior direction*

Variable	SS	Df	MS	SS	df	MS	F	<i>p</i>
raCOP	1.021	1	1.021	4.645	27	0.172	5.93	0.022
stdCOP	0.057	1	0.057	0.200	27	0.007	7.76	0.010
vCOP	0.132	1	0.132	1.078	27	0.040	3.30	0.080
raRAMB	1.102	1	1.102	4.209	27	0.156	7.07	0.013
stdRAMB	0.053	1	0.053	0.194	27	0.007	7.35	0.012
vRAMB	0.091	1	0.091	0.755	27	0.028	3.25	0.083
raTREMB	0.179	1	0.179	0.963	27	0.036	5.00	0.034
stdTREMB	0.001	1	0.001	0.003	27	0.000	6.15	0.020
vTREMB	0.041	1	0.041	0.242	27	0.009	4.58	0.041

**Table 2***Results of one-way ANOVA in the media – lateral direction*

Variable	SS	df	MS	SS	df	MS	F	<i>p</i>
raCOP	0.054	1	0.054	3.887	27	0.144	0.38	0.544
stdCOP	0.012	1	0.012	0.177	27	0.007	1.90	0.179
vCOP	0.012	1	0.012	0.447	27	0.017	0.75	0.393
raRAMB	0.114	1	0.114	3.377	27	0.125	0.91	0.348
stdRAMB	0.014	1	0.014	0.165	27	0.006	2.24	0.146
vRAMB	0.008	1	0.008	0.376	27	0.014	0.54	0.468
raTREMB	0.000	1	0.000	0.309	27	0.011	0.03	0.868
stdTREMB	0.000	1	0.000	0.001	27	0.000	0.25	0.619
vTREMB	0.004	1	0.004	0.040	27	0.001	2.90	0.100

## Discussion

The main aim of this study was to evaluate the effects of training experience on postural control. Significantly higher values of the measured posturographic variables were observed in wrestlers in the sagittal plane. These differences between athletes and the control group support our hypothesis. Due to the dynamic and rapid changes during wrestling competition, a complex set of abilities and skills should reach an optimal level for an athlete to be efficient in combat. This phenomenon may be observed in technical skills such as a lifting or back arch. It is essential that wrestlers possess strength and power; however, balance is also a significant component of performance.

These results partly correspond with data presented by other authors (Vuillerme et al., 2001; Hosseinimehr et al., 2009; Negahban et al., 2013). Our data are in agreement with results presented by Juras et al. (2013) that showed increased body sway in elite karate athletes. These authors assumed that it was caused by redundancy of the sensorimotor system. Same reason may explain the results obtained in well-trained competitive wrestlers. Proprioception is more likely essential to properly use the posture control impulses and facilitates the optimal performance of the motor task.

It should be emphasized that the results presented here justify the use of the rambling-trembling decomposition in posture studies in elite athletes. Although, the slow (rambling) and fast (trembling) components of COP trajectory are both calculated from the raw COP signal, they provide different information. Through the use of signal decomposition, significant differences were observed in mean values of the velocity of COP migrations in the sagittal plane. This was probably caused by sensorimotor features that were sufficiently addressed during wrestling training and competition. Balance training may lead to task-specific neural adaptations at the spinal and supraspinal levels, and this should be considered when planning and conducting physical conditioning. Logically, during strength and power training, neuromuscular control is also

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addressed. However, there remains an unanswered question if during proprioceptive training we can expect to see improvement in power variables. It seems that it may be beneficial to combine strength and proprioceptive training, and there are some arguments for this approach (Aman et al., 2015).

Another interesting issue is whether balance training can be as effective in improving motor function as it is in the improvement of motor abilities. Unfortunately, there are limited data on the influence of balance training on the technical skills of elite athletes. However, there are considerable data indicating that balance training improves skills in healthy, non-active subjects. Albeit, according to Zech et al. (2010) it is impossible to calculate the global effect of research with nonetheless because of insufficient data. A primary challenge in this regard is the fact that comprehensive and complex conditioning programs are usually dedicated to beginners and it is simply not possible to distinguish the separate effects of strength, flexibility and balance improvement. Alternatively, athletes are generally expected to have developed technical skills and an optimal level of motor abilities; therefore, subtle differences are always more difficult to observe. Furthermore, some methodological challenges limit potential research on athletes, such as the application of unified training programs for homogenous groups of athletes.

Further research of high methodological quality is needed to determine the effect of sports level on balance control and the potential influence of balance training on technical skills and sport performance in elite athletes.

## Conclusions

The effect of training experience on balance control observed in wrestlers is characterized by higher values of posturographic variables in the sagittal plane. This effect should be observed in younger athletes, as it could potentially be used as a selection criteria in the training process.

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