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Original Article

Comparison of balance skills, personality, and temperament of elite sports athletes and football players

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Abstract:
Problem Statement and Approach: Although balance skills and personality have been explored in the field of sports science, little is known about the relationship between the two factors. This study aims to investigate the association of postural balance with traits of personality and temperament. **Materials and Methods:** There were 73 participants in the cross-sectional study between ages 16 and 30 years (M = 21.29, SD = 2.47), and 59% were men. Three samples of participants consisted of Elite Athletes (EA, n = 17, 23.29%) in track and field from the Polish National Team, Football Players (FP, n = 32, 43.84%), and the Control Sample (CS, n = 24, 32.88%). Postural control was assessed on a force platform with a sampling frequency of 100 Hz, whereas personality and temperament were measured using the NEO-FFI and FCB-TI. **Results:** The EA and CS groups were more stable in the medial-lateral (ML) direction than in the FP group. In the anterior-posterior (AP) direction, the athletes from the EA group were more stable than the CS group. Openness to experience and emotional reactivity were associated with centre of pressure (COP) parameters. **Discussion:** The results of this study showed that EA and CS showed better stability than footballers in both the ML and AP directions. This study indicates that emotional reactivity as a temperamental trait is associated with postural stability. Among the big five traits of personality, openness solely was found to be related to postural balance skills. Openness is strongly linked with intelligence, which is determined by the efficiency and reliability of the central nervous system and the speed of a neural impulse. Additionally, plasticity as a trait includes openness and extraversion (low emotional reactivity) and may explain the relationship of both personality and temperament traits with balance skills. **Conclusions:** Openness to experience and emotional reactivity can be explained by postural balance skills. Further research should examine the association of balance skills with plasticity and intelligence. The present research may provide useful clues for sport selection and rehabilitation of sport injuries. Development of openness should be supported in team and individual sports that require excellent balance skills, such as track and field, artistic gymnastics, ice skating, and sky jumping.
Key Words: **COP parameters, track and field, football, Big Five model of personality, postural balance, Regulative Theory of Temperament**

Introduction

Maintaining body equilibrium requires multiple sensory complex processes, involving coordinated actions of sensory, motor, and biomechanical systems (Palmieri et al., 2002). A stable standing position is fundamental for most other motor activities. Postural control is a complex motor skill derived from the interaction of multiple sensorimotor processes (Horak, 2006) and combines the regulation of stability and orientation to the environment. Proper control of vertical posture is necessary for everyday life as well as in sports. The center of pressure (COP) analysis is most commonly used to assess postural sway. COP is the most frequently measured parameter from which various variables can be calculated to assess postural function (Paillard & Noe, 2015). Although various parameters that quantify postural control have been reviewed, no consensus has been reached as to which variable most accurately represents changes in postural control. Further research is necessary to identify which aspects of posture best represent a set of parameters (Palmieri et al., 2002). Analysis of the components contributing to postural behavior should be the subject of future research on postural function (Paillard & Noe, 2015).

Stabilographic studies have indicated that gender is not related to vertical posture control among young people. Differences between men and women in COP parameters are observed only in older people (Kim at al., 2010). Recent studies indicate that these differences may depend on somatic changes during the period of involution (Gong et al., 2019). In athletic training, special attention is paid to improving the ability to maintain and control body balance. Balance is one of the components of coordination skills. Postural stability has been

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examined in sports such as gymnastics (Vuillerme & Nougier 2004), judo (Perrin et al., 2002), rifle shooting (Era et al., 1996), skiing (Noe & Paillard, 2005), volleyball (Kuczyński et al., 2009), and football (Rogowska et al., 2014; Wojciechowska-Maszkowska et al., 2018). Balance skills have been explored in athletes at various levels of sports competitions (Anderson & Behm, 2005; Camliguney et al., 2012; Wiest et al., 2011; Zacharakis et al., 2020). The study showed increasing body sway in a sample of elite karate athletes compared to physical education university students (Juras et al., 2013). There is much controversy regarding body balance. Many years of sports training may significantly modify the redundancy of the postural control system and lead to the discipline-oriented optimal use of sensorimotor modalities responsible for balance (Bieć & Kuczyński, 2010).

Football players must perform motor skills and control their posture during a game while using visual information to collaborate with team members or to oppose the other team (Paillard & Noe, 2006). Football is a dynamic, open-minded contact sport wherein team members work together against opponent teammates. The main components of sports coordination skills include master training in balance, rhythm, spatial awareness, and quick responses in a constantly changing environment. Football players must have the skills of accelerating, decelerating, and changing direction. This is important throughout the match to increase the chance of players winning or performing effective defending maneuvers (Trecroci et al., 2018). However, the specificity of football increases the risk of losing balance and injury (López-Valenciano et al., 2020), in particular among amateur and female football players as compared to those at a professional sports level and males (Montalvo et.al., 2019).

Athletic motor activity differs from team sports in many ways. First and foremost, track and field is an individual noncontact sport that requires distinct motor skills, such as speed, endurance, and coordination, to ensure both sports success and injury prevention. Competitions in track and field disciplines rely on precise execution of repeated, cyclical body movements that are aimed at achieving a strictly defined and unchanging target. In team sports, unpredictability and quick reactions to a changing situation prevail, while in athletic competitions, success depends on willpower, masterful performance, and steadfast implementation of a strictly planned goal. Although the prevalence of injury among individual sports' athletes is several times lower in comparison to football players (Montalvo et al., 2019), it also results in decreased performance and prolonged absence from the sport activity (Sharma et al., 2020).

Personality and temperamental traits are basic psychological constructs that can explain and predict human behavior in sports. Personality is aimed at describing, explaining, and predicting the way human beings function in various aspects of life. The five-factor model of personality (Costa & McCrae, 1992) is most frequently used to describe the basic traits, such as neuroticism, extroversion, openness to experience, agreeableness, and conscientiousness. Women score higher than men on all five scales of personality (Zawadzki et al., 1998). Personality traits also change with age, with increasing intensity of neuroticism, extroversion, and openness to experience and decreasing agreeableness and conscientiousness. Most studies have indicated that participation in physical activity and sports is related to higher extroversion and conscientiousness and lower levels of neuroticism (Rhodes & Smith, 2006; Allen & Laborde, 2014; Rogowska, 2020). Success in sports (and in football, in particular) is associated with higher conscientiousness and lower neuroticism (Piedmont et al., 1999; Allen et al., 2011; Tran, 2012). Undergraduate athletes scored higher for extroversion, agreeableness, and conscientiousness and lower for neuroticism compared to nonathletes (Talyabee et al., 2013). A recent study showed that Polish students in physical education (PE) scored lower for neuroticism, openness, and agreeableness than students from other faculties (a control sample) (Rogowska, 2020). Additionally, team sport athletes scored higher in extroversion than nonathlete physical education students.

The Regulative Theory of Temperament (RTT) assumes that people modify their behavior according to the needs of stimulation (Strelau, 1983). The structure of temperament consists of the six following traits: Briskness (BR), Perseveration (PE), Sensory Sensitivity (SS), Emotional Reactivity (ER), Endurance (EN), and Activity (AC) (Strelau, 2018). Temperament concerns emotional and stylistic characteristics of behavior, whereas personality is based on the self-concept and greater interaction with the environment (Strelau, 2002). Because temperamental traits emerge earlier in life than personality, they can directly and strongly influence the development of personality traits (Strelau, 2018). Research found that women scored higher than men in ER, PE, and SS but lower in BR, EN, and AC (Zawadzki & Strelau, 1997). The association between temperament and age is curvilinear and U-shaped for ER, PE, and AC and is an inverted U-shape for EN, SS, and BR (Zawadzki & Strelau, 1997). Athletes typically demonstrate a low level of ER and high levels of AC and EN (Gracz & Sankowski, 2007; Magier & Magier, 2015; Rogowska & Wojciechowska-Maszkowska, 2020; Unrug & Malesza, 2012). Additionally, a positive association has been found between the activity facet trait of extroversion and physical activity in a meta-analytic review (Rhodes & Pfaeffli, 2012; Allen & Laborde, 2014). Apart from AC, temperamental traits are not strongly related to physical activity because research has showed ambiguous connections in particular studies (Guszkowska & Rychta, 2007; Bernatowicz et al., 2015; Karvonen et al., 2020).

Athletes experience numerous injuries (Alizadeh et al., 2012; Barber Foss et al., 2014), which can be related to poor balance skills (Hrysomallis, 2011) as well as to select psychological factors (Devantier, 2011; Deroche et al., 2012; Slimani et al., 2018). A systematic review and meta-analysis showed that trait anxiety, perceived mastery, and experienced stress are the main predictors of injury rates among soccer players (Slimani et al., 2018). However, psychologically based interventions may significantly reduce injury rates. A better understanding of injury risk factors is necessary to identify injury-prone athletes and develop appropriate injury prevention plans. The assumption of an association between balance skills and personality or temperament traits is based on the shared features of the nervous system. All three abovementioned variables are determined both genetically and environmentally and develop based on the interaction between these factors. Furthermore, both motor skills and psychological dimensions seem to play a crucial role in sports success as well as injury risk. Previous studies have been promising and seem to confirm these assumptions. It was found that personality and temperament may be related to balance skills (Rogowska et al., 2014; Wojciechowska-Maszkowska et al., 2018). However, research on the relationship between personality and balance is scarce. This study aimed to compare balance skills, personality, and temperament traits between elite sports athletes, football players, and physiotherapy students as a control sample. The association between all variables was examined. Demographic variables, such as gender and age, were controlled in this study.

Based on previous research (Palmer et al., 2015; Zemková & Hamar, 2018), it is hypothesized that elite sports athletes will differ in postural balance from football players and also from a control group of nonathletes. Overall, athletes and football players should demonstrate better balance skills than the control sample (Barone et al., 2011; Ringhof & Stein, 2018). Consistent with previous studies, we also assume that postural balance is related to conscientiousness as a personality trait (Rogowska et al., 2014) and sensory sensitivity as a temperament trait (Wojciechowska-Maszkowska et al., 2018).

Materials & methods

Study design

Specialized sports training starts early in childhood or adolescence and may affect the athlete's postural stability in adulthood. The present case–control study compares two samples of adult athletes at various levels of sports competitions (world versus regional championships) with a group of nonathletes as the control sample. We assumed that sports training differs in intensity, frequency, and strength depending on the level, which may affect group differences in balance skills. We hypothesize that the differences in sporting level are related to the intensity, frequency, and strength of the training. Elite athletes (EA) represent professional individual sports engagement with everyday cyclical training for many hours and frequent participation in competitions at the highest performance level (world championships). The second comparative sample consisted of football players (FP). Football is a team and contact sport and has the highest injury risk. The FP group included undergraduate students in the physical education faculty and members of the Academic Sports Association in the football section. Every day for a few hours, they had sports training, focused mainly on speed, energy, reaction, and coordination. They also participated in competitions at the academic level (regional championships). The third, control sample (CS) included undergraduate students of the physiotherapy faculty that matched the EA and FB groups in terms of age. However, students from the CS were not engaged in sports. The inclusion criteria for all participants in the study were: written informed consent of the participant, level of engagement in sports (professional, academic, or none), and young adulthood. The exclusion criteria were upper or lower limb injuries, dizziness, or disease.

The research was conducted from October 28, 2010 to April 26, 2011. FB and CS samples were examined at the biomechanics workshop of the Faculty of Physical Education and Physiotherapy at the Opole University of Technology, Poland. The CS sample participated in the study during biomechanics classes that were for course credit. The FB sample was examined after classes at the university. The EA sample was examined with the consent of the Polish Athletic Association on April 26, 2011 during a sports grouping at the Central Sports Centre in Spała, Poland.

Before the test, the participants were familiar with information about the study, including the purpose, methodology, and procedures. To take part in the test, they voluntarily signed a written consent form to participate. The paper and pencil questionnaires to assess personality and temperament traits (the NEO-FFI and FCB-TI) were completed after the balance measurement. All recruited participants completed both postural tests and psychological questionnaires; no one was excluded from further analysis. Institutional Review Board approval was obtained for the study procedures for recruitment, data collection, and analysis. Experiments were conducted following the Helsinki Declaration.

Study procedure of postural control

The subjects were asked to stand on a platform for 20 s twice: once with their eyes open and once with their eyes closed. According to the methodology used, the participants were requested to stand barefoot with a 14-degree angle between the feet and a distance of 17 cm between the heels with their arms at their sides. The test was invalid if the participant moved a leg or used an arm. Subjects rested for approximately 1 min between the trials.

Participants

Seventy-three people participated in the study between ages 16 and 30 years (M = 21.29, SD = 2.47) with a slight but not significant prevalence of men (n = 43, 58.90%) in the total sample, $\chi^2(1) = 1.16$, $p = 0.28$. The mean height of the study sample was 176 cm, whereas the mean weight was 72 kg. The participants were grouped into the following three samples: 1) Elite Athletes (AE, *n* = 17, 23.29%) are professional athletes who represent the Polish National Team in track and field and compete in world championships; 2) Football Players (FP, *n* = 32, 43.84%) are amateur athletes who compete at a regional level; and 3) the Control Sample (CS, *n* = 24, 32.88%) consisted of physiotherapy students who are not involved in any sports activity. Both the FP and CS samples consisted of undergraduate students at a large university in the south of Poland. The EA athletes represented specializations in sprinting (*n* = 6), sports walking (*n* = 4), combined events (*n* = 4), pole vaulting (*n* = 2), and discus throwing (*n* = 1). The ratio of men to women in each group was 12:5 in the EA group, 22:10 in the FP sample, and 9:15 among the control group. The demographic data, such as age, height, and weight of particular samples, are included in Table 1.

Table 1. Demographic data for each group of participants

Demograpic variables	Control Sample		Elite Athletes		Football Players		Total sample	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age [years]	20.29	0.86	20.12	3.85	22.66	1.60	21.29	2.47
Height [cm]	172.81	8.65	179.29	6.29	176.78	9.14	176.20	8.63
Weight [kg]	70.47	10.14	71.84	7.61	72.76	12.87	71.79	10.86

Measures

Postural balance

The posturographic examination was performed on a force platform (Type 9286AA, Kistler Instrument AG, Winterthur, Switzerland) with a sampling frequency of 100 Hz. Based on the recorded signal COP, average values for the amplitude parameters of the stabilograph in the anterior–posterior (AP) and medial–lateral (ML) directions of the movement were calculated. Linear parameters included the standard deviation (SD), range (RA) of the time series, and mean velocity (MV). Sample entropy (SE) as a nonlinear parameter was measured to assess the irregularity or unpredictability of a time series (Donker et al., 2007; Roerdink et al., 2011). Overall, lower values for these parameters indicated more efficient balance control.

Personality

Personality traits were assessed by the NEO Five-Factor Inventory (NEO-FFI). The NEO-FFI comprises 60 items in five subscales: Neuroticism, Extroversion, Openness to Experience, Agreeableness, and Conscientiousness. To answer the questions, participants used a 5-point Likert scale, ranging from 0 = strongly disagree to 4 = strongly agree. The reliability of the NEO-FFI indicated an acceptable level of internal consistency (Cronbach's α) in previous research (Costa & McCrae, 1992) as well as in the Polish version of the questionnaire (Zawadzki et al., 1998) for the following scales: Neuroticism (α = 0.80), Extraversion (α = 0.77), Openness (α = 0.68), Agreeableness (α = 0.68), and Conscientiousness (α = 0.82). The Cronbach's alphas for the scales of Neuroticism, Extroversion, Openness to Experience, Agreeableness, and Conscientiousness in the present study were 0.85, 0.80, 0.55, 0.76, and 0.81, respectively.

Temperament

A standard self-reported questionnaire was used to measure temperament traits according to the Regulative Theory of Temperament (RTT), as developed by Strelau (Strelau, 1996; Strelau, 1998). Each of the six scales (Activity, Briskness, Emotional Reactivity, Endurance, Perseveration, and Sensory Sensitivity) comprises 20 items that require "yes" or "no" answers. The FCB-TI in the Polish version (Zawadzki & Strelau, 1997) has revealed sufficient reliability for the following scales: Briskness (α = 0.77), Perseveration (α = 0.79), Sensory Sensitivity (α = 0.73), Emotional Reactivity (α = 0.83), Endurance (α = 0.85) and Activity (α = 0.83). In the present study (*N* = 73), the internal reliability (Cronbach's α) values were 0.54, 0.78, 0.63, 0.85, 0.82, and 0.73 for the BR, PE, SS, ER, EN, and AC scales, respectively.

Statistical analysis

Missing data in the questionnaires were replaced by the sample average. There was one participant with two missing data points (one in the NEO-FFI and one in the FBC-TI). The reliability (Cronbach's α) of the FCB-TI scales and descriptive statistics (range, mean, 95% confidence interval, standard deviation, and standard error) were performed in the first step of statistical analysis. The differences in postural balance, personality, and temperament traits between the EA, FP, and CS samples were assessed using one-way ANOVA. Additionally, two-way repeated measure ANOVA was conducted to examine the group (EA, FP, and CS) differences in postural balance. The particular COP parameters were considered as a dependent variable, and group was considered as a factor variable. "Repeated measures" refers to the conditions of eyes open and eyes closed for each COP parameter. Fisher's Least Significant Difference (LSD) post hoc test was performed to assess significant differences between samples. Finally, a series of Pearson's correlation and hierarchical multiple regression analyses were conducted to clarify the relationship between personality and temperament traits as a dependent variable and COP parameters as an independent variable. To avoid multicollinearity among COP parameters, we conducted four models of hierarchical two-step regression analyses. The two regression models refer to the eyes open (EO) condition in the ML and AP planes, respectively. The two other models concern the eyes closed (EC) condition in the ML and AP planes. The first stage of the regression analysis included demographic variables (group, gender, and age), whereas the second stage included four COP parameters (SD, RA, MV, and SE) in each subsequent model. All statistical analyses were performed using STATISTICA 13.1 software. We assumed an acceptable level of significance at a *p* value equal to 0.05 (5%).

Results

The descriptive statistics for the COP parameters, personality, and temperament traits in the total sample (*N* = 73) are shown in Table 2. Because the Kolmogorov–Smirnov *d* test showed normal distribution for all variables, parametric tests were performed for further statistical analyses. A series of one-way ANOVA was performed for COP parameters, personality, and temperament as the dependent variable and group (EA, FB, and CS) as the independent variable. Numerous group differences in postural balance were found, as shown in Table 3. Among the personality traits, the CS sample only differed from the EA and FP groups in having higher AC. No significant differences between the three groups were noted in terms of temperament.

Table 2. Descriptive statistics for the total sample

	Range			95% CI			
Variables	Min.	Max.	M	UP	LL	SD	SE
COP Parameters - Eyes Open							
SD ML	1.13	5.17	2.4	[2.22,	2.58]	0.79	0.09
SD AP	1.76	8.78	3.87	[3.51,	4.23]	1.55	0.18
RA ML	4.55	24.39	12.56	[11.55,	13.58]	4.35	0.51
RA AP	8.26	42.42	18.31	[16.82,	19.8]	6.39	0.75
MV ML	4.08	10.18	6.74	[6.4,	7.09]	1.48	0.17
MV AP	5.34	14.01	9.56	[9.14,	9.99]	1.81	0.21
SE ML	0.4	1.42	0.89	[0.83,	0.95]	0.25	0.03
SE AP	0.26	1.55	0.87	[0.81,	0.94]	0.28	0.03
COP Parameters - Eyes Closed							
SD ML	1.22	6.02	2.95	[1.22,	6.02]	1.14	0.13
SD AP	2.16	11.41	4.8	[2.16,	11.41]	1.66	0.19
RA ML	5.73	34.52	15.4	[5.73,	34.52]	6.03	0.71
RA AP	10.78	52.69	23.65	[10.78,	52.69]	7.36	0.86
MV ML	4.21	28.55	9.12	[4.21,	28.55]	3.41	0.4
MV AP	6.54	48.94	14.59	[6.54,	48.94]	5.47	0.64
SE ML	0.48	1.43	0.96	[0.48,	1.43]	0.25	0.03
SE AP	0.46	1.42	0.92	[0.46,	1.42]	0.2	0.02
Personality traits							
Neuroticism	1	38	17.37	[15.48,	19.26]	8.11	0.95
Extraversion	20	44	32.14	[30.69,	33.58]	6.18	0.72
Openness	15	39	25.3	[24.06,	26.54]	5.33	0.62
Agreeableness	17	40	29.33	[27.86,	30.8]	6.31	0.74
Conscientiousness	14	45	33.82	[32.34,	35.3]	6.34	0.74
Temperament traits							
Sensory Sensitivity	8	20	14.6	[13.95,	15.26]	2.8	0.33
Activity	4	19	12.89	[12.02,	13.76]	3.71	0.43
Perseveration	0	19	12.16	[11.19,	13.14]	4.17	0.49
Briskness	9	20	15.88	[15.31,	16.44]	2.41	0.28
Endurance	2	19	12.16	[11.12,	13.21]	4.5	0.53
Emotional Reactivity	1	19	7.52	[6.43,	8.61]	4.68	0.55

COP: center of pressure; SD: standard deviation; RA: range; MV: mean velocity; SE: entropy; AP: anterior–posterior; ML: medial–lateral

As shown in Tables 4 and 5, a significant correlation was found between the selected COP parameters and the traits of personality and temperament. PE and ER are positively correlated with SE, AP, and EO, and SE, ML, and EC are positively correlated with ER. Among personality traits, N is positively correlated with MV, ML, and EO, and MV, ML, and EO are negatively correlated with MV, ML, and EO, while A is positively correlated with SE, ML, and EO.

Table 3. Results of one-way ANOVA for COP parameters, personality, and temperament traits

	EA (n = 17)		FP (n = 32)		CS (n = 24)				
Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	F(2, 70)	p	LSD post-hoc
COP Parameters - Eyes Open									
SD ML	1.95	0.63	2.76	0.75	2.24	0.75	7.86	0.00	FP>EA***, FP>CS**
SD AP	3.66	1.15	4.26	1.79	3.48	1.38	1.98	0.15	
RA ML	10.26	3.56	14.57	4.23	11.52	3.95	7.70	0.00	FP>EA***, FP>CS**
RA AP	17.15	4.41	19.91	7.81	17.00	5.06	1.83	0.17	
MV ML	6.68	1.34	6.89	1.47	6.59	1.62	0.31	0.74	
MV AP	9.62	1.97	9.02	1.83	10.25	1.46	3.35	0.04	FP>CS*
SE ML	0.90	0.23	0.75	0.18	1.08	0.22	17.99	0.00	CS>EA**,CS>FP***, EA>FP*
SE AP	1.03	0.27	0.80	0.29	0.85	0.24	4.21	0.02	EA>CS*, EA>FP**

COP Parameters - Eyes Closed									
SD ML	2.12	0.69	2.98	1.18	2.70	1.21	3.38	0.04	FP>EA*
SD AP	5.19	2.11	4.44	1.73	3.81	0.83	3.68	0.03	EA>CS**
RA ML	11.48	3.94	15.93	6.62	13.18	5.79	3.59	0.03	FP>EA*
RA AP	25.33	9.00	22.13	7.50	19.26	4.64	3.65	0.03	EA>CS**
MV ML	8.77	2.07	8.69	4.50	7.51	2.26	1.01	0.37	
MV AP	14.51	4.25	12.74	7.33	13.24	2.68	0.58	0.56	
SE ML	0.97	0.18	0.80	0.22	0.99	0.27	5.31	0.01	CS>FP**, EA>FP*
SE AP	0.96	0.23	0.83	0.21	0.87	0.17	2.20	0.12	
Personality									
N	18.35	9.06	16.63	7.10	17.67	8.89	0.27	0.76	
E	33.00	6.02	32.41	5.83	31.17	6.85	0.48	0.62	
O	26.06	5.36	24.34	5.09	26.04	5.64	0.92	0.40	
A	26.53	6.06	28.63	6.49	32.25	5.19	4.93	0.01	CS>EA***, CS>FP*
C	34.29	7.17	33.59	6.13	33.79	6.26	0.07	0.94	
Temperament									
SS	14.12	2.60	15.16	3.01	14.21	2.62	1.12	0.33	
AC	13.18	3.49	13.22	2.84	12.25	4.81	0.53	0.59	
PE	11.65	4.81	11.94	3.53	12.83	4.56	0.48	0.62	
BR	15.24	2.11	16.28	2.58	15.79	2.36	1.07	0.35	
EN	13.12	4.69	10.75	4.66	13.38	3.70	2.99	0.06	
ER	7.53	4.43	6.84	4.55	8.42	5.06	0.77	0.47	

COP: center of pressure; SD: standard deviation; RA: range; MV: mean velocity; SE: entropy; AP: anterior–posterior; ML: medial–lateral; N: Neuroticism, E: Extroversion, O: Openness, A: Agreeableness, C: Conscientiousness, SS: Sensory Sensitivity, AC: Activity, PE: Perseveration, BR: Briskness, EN: Endurance, ER: Emotional Reactivity. $p^* < .05$, $p^{**} < .01$, $p^{***} < .001$.

A series of hierarchical multiple regression analyses was performed for particular temperament (SS, AC, BR, PE, EN, and ER) and personality traits (N, E, O, A, and C) as an explained variable with predictors, such as demographic variables (group, sex, and age), and COP parameters (SD, RA, MV, and SE), in both EO and EC conditions and in both the ML and AP planes. All regression models met the assumptions of normality of residuals, linearity, homoscedasticity, and absence of multicollinearity (using VIF values < 10). Most of the regression models failed, demonstrating poor R^2 and F-tests of overall significance with insufficient p values.

We conclude that these regression models did not fit the data; thus, the assumption about the relationship between variables was not confirmed for the majority of temperamental and personality traits. However, emotional reactivity demonstrated a significantly positive association with SD ($\beta = 0.98$, $p < 0.01$) and a negative one with RA ($\beta = –0.86$, $p < 0.01$) but solely for the ML plane and EO condition. Model 1 in the second step of the regression analysis explained 20% of the ER variance with $R^2 = 0.20$, $R^2_{adj.} = 0.11$, $\Delta R^2 = 0.14$, $F(7,65) = 2.29$, $p < 0.05$. Furthermore, Model 1, in the second step of the regression analysis, showed significant predictors of openness among sex ($\beta = –0.23$, $p < 0.05$), and COP parameters in the ML plane and EO condition such as SD ($\beta = –0.78$, $p < 0.01$), RA ($\beta = 1.04$, $p < 0.001$), and MV ($\beta = –0.51$, $p < 0.001$). This model explained 35% of the openness variance with $R^2 = 0.35$, $R^2_{adj.} = 0.28$, $\Delta R^2 = 0.25$, $F(7,65) = 5.08$, $p < 0.001$. Additionally, agreeableness was solely associated with gender. The agreeableness explained by sex and the set of variables in particular regression models ranged from 19% to 23%.

Table 4. Correlation between COP parameters and temperament traits

Variable	SS	AC	PE	BR	EN	ER
sd ml_EO	0.08	0.04	0.11	0.01	-0.03	0.05
sd ap_EO	-0.15	-0.02	-0.21	-0.06	-0.07	-0.14
ra ml_EO	0.07	0.15	-0.04	0.06	0.07	-0.08
ra ap_EO	-0.13	0.01	-0.22	0.02	-0.06	-0.20
mv ml_EO	-0.03	-0.10	0.11	-0.01	0.07	0.08
mv ap_EO	0.06	0.02	0.18	0.01	0.19	0.12
se ml_EO	-0.08	-0.18	0.06	0.01	0.13	0.13
se ap_EO	0.07	-0.07	0.27*	-0.03	0.05	0.27*
sd ml_EC	0.00	-0.05	0.08	0.02	-0.07	-0.05
sd ap_EC	-0.01	-0.06	0.03	-0.16	-0.14	0.03
ra ml_EC	0.07	-0.06	0.05	0.02	-0.10	-0.05
ra ap_EC	0.05	-0.04	0.06	-0.06	-0.17	0.04
mv ml_EC	0.00	-0.03	0.14	0.04	0.00	0.08
mv ap_EC	0.06	0.02	0.16	0.03	-0.01	0.09
se ml_EC	-0.01	-0.02	0.06	0.00	0.14	0.25*
se ap_EC	0.07	0.08	0.16	0.02	0.08	0.18

COP: center of pressure; SD: standard deviation; RA: range; MV: mean velocity; SE: entropy; AP: anterior–posterior; ML: medial–lateral; SS: Sensory Sensitivity, AC: Activity, PE: Perseveration, BR: Briskness, EN: Endurance, ER: Emotional Reactivity. $p* < .05$.

Table 5. Correlation between COP parameters and personality traits

Variable	N	E	O	A	C
sd ml_EO	0.10	-0.04	-0.02	-0.17	-0.18
sd ap_EO	0.08	0.07	-0.19	-0.04	0.06
ra ml_EO	0.06	0.00	0.08	-0.18	-0.12
ra ap_EO	0.02	0.10	-0.15	-0.06	0.02
mv ml_EO	0.25*	-0.17	-0.27*	-0.12	-0.04
mv ap_EO	0.00	-0.03	-0.03	0.03	0.05
se ml_EO	0.04	-0.13	-0.04	0.27*	0.15
se ap_EO	0.01	-0.10	0.16	-0.03	0.00
sd ml_EC	0.10	-0.09	-0.15	-0.10	-0.06
sd ap_EC	0.07	0.04	-0.03	-0.20	-0.07
ra ml_EC	0.18	-0.13	-0.15	-0.12	-0.05
ra ap_EC	0.12	-0.05	-0.01	-0.17	-0.09
mv ml_EC	0.26*	-0.23	-0.17	-0.16	-0.17
mv ap_EC	0.20	-0.18	-0.05	-0.07	-0.18
se ml_EC	0.06	-0.17	0.05	0.18	0.05
se ap_EC	0.09	-0.16	0.01	0.05	0.09

COP: center of pressure; SD: standard deviation; RA: range; MV: mean velocity; SE: entropy; AP: anterior–posterior; ML: medial–lateral; N: Neuroticism, E: Extroversion, O: Openness, A: Agreeableness, C: Conscientiousness. $p* < 0.05$.

Discussion

Group differences in postural balance skills

Our study indicated that there are significant differences in the COP parameters between the three following samples: athletes (EA), football players (FP), and the control sample (CS). The FP group demonstrated significantly higher body variability in the ML direction under visual control conditions than EA and CS. Entropy in this direction was significantly higher in the CS group in comparison to EA and FP and in the AE group compared to FP. However, in the AP direction, the FP showed a higher speed of body sway than people from the CS group. An analysis of changes in COP without visual inspection showed that the body sway of the FP group was higher than in the EA sample with regards to the variability of COP. In contrast, entropy was significantly higher in the CS and AE group compared to that of the FP group. This may indicate a specific adaptation of posture control among FP that develops consistently with the requirements of the sport (movement and other motor activities on the pitch). Our research is consistent with Paillard's previous findings and showed a greater dependence of posture control on eyesight in the EA and FB than in the CS group (Paillard et al., 2002).

Consistent with previous research (Kim et al., 2010), balance skills are not related to gender. Body posture control is an individual feature that develops on body build, age, and level of training. Numerous studies have shown that balance-oriented exercises can improve adaptive posture control and that, the higher the level of competition, the more stable the posture is in soccer (Anderson & Behm, 2005; Paillard & Noe, 2006; Mkaouer et al., 2017; Zemková & Hamar, 2018). The postural regulation of subjects with a better sports performance level was less disturbed by sensorial manipulation than that of sportsmen with a lower level of performance. There is a close relationship between the level at which the sport is played and the effectiveness of postural regulation (Paillard et al., 2007). Barone et al. showed that, in soccer, the higher the level of competition, the more stable the posture and the less visual information required for postural maintenance (Barone et al., 2011).

COP parameter values testify to global coordination abilities concerning the equilibrium system (Winter, 1995). Higher COP variability may indicate various regulatory mechanisms resulting in the ability to maintain balance by triggering random movements. The results of Yamada et al. indicated that, in football players, along with an increase in sports advancement, the instability in the AP plane increases (Yamada et al., 2012). Other studies have indicated that specific training contributes to a decrease in the variability of body excretions (Jakobsen et al., 2011). COP parameter values testify to global coordination abilities being related to the equilibrium system (Winter, 1995). Higher COP variability may indicate various regulatory mechanisms, resulting in the ability to maintain balance by triggering random movements.

Our findings differ from Bieć and Kuczyński, who stated that footballers have better body balance control compared to nonathletes (2010). The difference in our results may mean that the age of the respondents, and thus the level of training, can explain the differences and dependencies in the changes in COP values. Our research is consistent and supports the data presented by Wojciechowska-Maszkowska et al. (2018). Other studies have indicated that football players and gymnasts are not very different in terms of static or dynamic control (Bressel et al., 2007).

Group differences in personality and temperament

Surprisingly, neither personality nor temperament traits differed significantly between the EA, FP, and CS samples in this study, except for agreeableness, as was demonstrated by the results of the one-way ANOVA. A recent study indicated that academic team sports players scored significantly lower for neuroticism, openness, and agreeableness and higher for extroversion than students studying for a physical education major (Rogowska, 2020). This study seems partially consistent since agreeableness was significantly lower in both our EA and FP samples compared to the CS group (which includes physiotherapy students). Another study compared personality traits between individual and team sport athletes (Nia & Besharat, 2010). Higher agreeableness in team sports players was found when compared to individual sports samples. Similar to the present study, no two groups of athletes were the same in terms of neuroticism, extraversion, conscientiousness, and openness. However, Talyabee et al. (2013) showed that nonathletes scored lower than an academic sample of athletes for agreeableness, extroversion, and conscientiousness and higher for neuroticism. Agreeableness seems to be a very valuable trait in team sports. A systematic review indicates that sport participants with high levels of agreeableness report more favorable relationships with their teammates and coaches (Allen & Laborde, 2014). Highly agreeable athletes also demonstrate less team-related conflict and better cooperation and relationships with other team members (Laios & Alexopoulos, 2014). The role in the team (i.e., leader, star) may also determine the usefulness of higher or lower agreeableness, as indicated by Kim et al. (2018). A high inconsistency exists between studies, which may be determined by cultural differences or perhaps the specific sport discipline.

Nevertheless, the present study indicates that an essential trait that differs between physical education students and professional athletes is agreeableness. People who score high on agreeableness are perceived as empathetic and altruistic, whereas a low agreeableness score relates to selfish behavior and a tendency to compete with others rather than cooperate (Kaufman et al. 2019). Because sporting is fundamentally related to competition, a lower level of agreeableness may be a beneficial trait in sports achievement (Hogan & Sherman, 2020). Thus, lower agreeableness may be related to frequent participation in competitions, a high level of aspiration, and a need for achievement.

However, the above interpretation may be false because the results of the two-way ANOVA did not confirm the above group differences. Instead, gender differences were found, which may explain the previously mentioned group differences. The CS women dominated and scored higher in terms of agreeableness in this study. Furthermore, gender was a significant predictor of agreeableness, explaining approximately 20% of its variance. Moreover, gender differences were found in terms of openness to experience. The higher levels of agreeableness and openness among women compared to men are consistent with previous studies about individual differences in personality (Costa & McCrae, 1992; Zawadzki et al., 1998). However, the present study did not find significant sex differences for neuroticism, extroversion, and conscientiousness or for all temperamental traits, which is not consistent with previously reported studies (Costa & McCrae, 1992; Zawadzki et al., 1998; Allen & Laborde, 2014). This result may be caused by the specifics of the participants in the study, not the large sample size.

Finally, the two-way ANOVA also showed that the FP sample reported lower scores in terms of endurance as a temperamental trait than in the EA and CS groups. Endurance manifests in the tendency to react adequately in situations that require long-term activity or intense behavior. This result is not consistent with a previous study, which did not show any significant differences between team and individual sports in terms of temperamental traits (Sękowski & Berej, 2019). Independent of the sports discipline, athletes should be characterized by a generally high level of endurance. However, the differences found in this study were small; thus, it may be a random effect of the small sample size.

Association of postural balance with traits of personality and temperament

The main goal of the study was to look for relationships between COP indicators and temperament and personality traits. The novelty of this study was the combination of biomechanical and psychological data for understanding postural behavior. Although a series of correlations were found between select COP parameters and traits of personality and temperament, the associations were weak in this study and may not be considered sufficient, given multiple comparisons. Indeed, a series of regression analyses did not confirm the previous relationships. Surprisingly, among all personality and temperamental traits, only emotional reactivity and openness demonstrated a significant association with the selected COP parameters, but these were in the ML plane and EO condition exclusively. The predictors of emotional reactivity were high SD and low RA, whereas predictors of openness were high RA and low SD and MV.

The regulatory function of temperament is best manifested in the ER trait: seeking or avoiding stimulation and adjusting the level of stimulation to individual needs. People with low levels of ER are resistant to stress, show less neurotic behavior, cope better with stress, have better indices of mental health, and prefer events with a high level of stimulation compared to highly ER individuals (Strelau, 2018). Thus, a low level of ER seems to play a crucial role in sports. Indeed, studies indicated that athletes demonstrate a significantly lower level of ER than a nonathlete population (Janssen et al. 2017,). ER has been found to be an essential trait for predicting physical activity and high sports achievement (Gracz & Sankowski, 2007; Magier & Magier, 2015; Janssen et al., 2017; Karvonen et al. 2020). Emotional reactivity facilitates quick reactions to emotional stimuli and heightened emotional sensitivity and intensity (Liang et al., 2019). The present study indicated that the pattern of coping with a loss of equilibrium is based on increasing SD and decreasing RA in the ML plane while standing on the stabilographic platform with eyes open in high ER individuals.

In contrast, people with higher scores for openness to experience demonstrate the opposite strategy. They cope with the loss of balance by reducing SD and MV in the ML plan and increasing RA when their eyes are open. Open people actively seek new and varied experiences and are apt to be particularly reactive and thoughtful about the ideas they encounter. The openness trait involves motivation, a need for variety, cognitive sentience, and a need for deep understanding, which may lead to higher academic performance in undergraduates (Komarraju et al., 2011). Research indicates that openness is related to physiological responses to chronic social stress (Lü et al., 2016). Herzhoff and Tackett found three facets of openness in children: intellect, imagination, and sensitivity (Herzhoff & Tackett, 2012). Openness is the one personality trait that is the most strongly related to creativity and intelligence. Moreover, the heritability of openness mirrors the heritability of intelligence (Costa & McCrae, 1992). Conversely, low openness to experience was found as a preclinical marker of incipient cognitive decline in older adults (Williams et al., 2013). Intelligence has a strong genetic basis and manifests at the neuronal level in a shorter time and with a more accurate response for stimulus. Research indicates that intelligence is related to the reliability and efficiency of the neuronal system and the speed of a neural impulse (Barbey, 2018; Lengler et al., 2013; Sengupta et al., 2013). Furthermore, plasticity as a trait includes openness and extraversion and may explain the relationship with balance skills (Musek, 2017). Thus, openness and balance may share a common neuronal mechanism that is responsible for adaptation to the environment. This needs to be tested in future research because COP parameters may explain 35% of the openness variance.

Of note, the nervous system is much more involved in the control of the position of the body in the ML plane in comparison to that in the AP plane. Control of the human body posture is characterized by greater stability in the AP plane because of the two-legged support of the body during vertical standing. Furthermore, research has shown that conscious control of the body posture is less effective than automatic (Yardley et al., 2001; Borzucka & Kuczyński, 2005; Huffman et al., 2009). The range (RA) and variability (SD) of body sway in vertical posture are dependent on each other. An increase in the values of both parameters may indicate less stability of the equilibrium system, and a decrease in the values of both parameters may indicate better stability. However, lower values of mean velocity (MV) indicate a certain calm control (Paillard & Noe, 2015). We can speculate that people with heightened openness to experience tended toward a higher risk of losing balance by increasing their range of sway, but concurrently they tried to restore balance control by decreasing SD and MV.

However, high ER people may react more emotionally and automatically than consciously by reducing RA but simultaneously increasing SD. This may be related to the worst cognitive flexibility. Low ER has been found to be associated with higher-order flexibility and cognitive control (Gruszka & Owen, 2015), more successful self-control (Nęcka et al., 2019), high energetic arousal and hedonic tone of arousal, and low tense arousal (Jankowski & Zajenkowski, 2012). Conversely, high ER people present higher emotional tension and cognitive stiffness. Our study is not consistent with previous research. Wojciechowska-Maszkowska et al. (2018) found a relationship between body balance and conscientiousness among football players. SD, AP, and EC were significantly higher for more conscientious athletes, whereas less conscientious athletes showed higher SD, AP, and EO. Previous research found an interaction between static balance and sensory sensitivity in a sample of football players (Rogowska et al. 2014). Individuals with heightened sensory sensitivity showed lower SD, ML, and EC and higher SD, AP, and EC. There may be an infinite number of variables that mediate the relationship between postural balance and personality or temperament. Future research should focus on further exploration of this association.

Limitations of the study

There were some limitations of this study. First, the sample size was not large because there is a small total number of elite athletes in the country. Further studies should consider a larger sample size, e.g., by including elite athletes from various countries. Second, the age of the participants was limited to early adulthood. Further studies should include people with a wide range of ages and experience of sports training. The group of athletes consisted of two selected sports disciplines; thus, the results of this study may not be generalized to other individual and team sports. Further studies should include other sports disciplines. Finally, personality and temperament traits were measured using a self-reported survey. Other experimental methods for assessing behavior concerning personality and temperament traits should be taken into consideration in future research.

Conclusions

This study indicates that people from EA and CS groups were more stable in the ML direction than those in the FP group. Changes in the AP direction of COP indicate that the athletes from the EA group were more stable than the CS group in terms of body change and variability. Thus, the results of this study showed that EA and CS have better stability than footballers in both the ML and AP directions. Among the personality and temperament traits, emotional reactivity and openness to experience appear to be the only two traits that are associated with coordination skills such as maintaining equilibrium on the stabilographic platform. Our results indicate that people with heightened ER cope with body sway in the ML plane using the opposite strategy to people with high scores of openness when all sensory systems are available (eyes open). Perhaps the inclusion of components, such as personality and temperament, in the assessment of posture control can enrich our knowledge of adaptive behavior. Sports psychologists and trainers could use the results of this study to optimize the training process. Balance training with sight control should be individualized and dependent on the levels of emotional reactivity and openness to experience. This research may provide useful clues for sport selection and rehabilitation of sport injuries. Development of openness should be supported in team and individual sports that require excellent balance skills, such as track and field, artistic gymnastics, ice skating, and sky jumping. A specialized conditioning program (Hianik et al., 2017), specific balance and proprioceptive programs (Zacharakis et al., 2020), and the conjugate influence method (Palomares et al., 2019) may be valuable for the improvement of balance skills in athletes.

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