A comparison of the balance skills, personality, and temperament of elite sports athletes and football players

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Research article

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Abstract

Background: 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. The differences between elite athletes, football players, and the control sample will also be examined.

Methods: There were 73 participants in the cross-sectional study, aged between 16 and 30 years (M = 21.29, SD = 2.47), including 59% men. Three samples of participants consisted of elite athletes (AE, n = 17, 23.29%) 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 (Type 9286AA, Kistler Instrumente AG, Winterthur, Switzerland) with a sampling frequency of 100 Hz. The center of pressure (COP) parameter was measured for 20 s in both conditions with eyes open, and eyes closed, in both directions, anterior—posterior (AP) and medial—lateral (ML). The COP parameters include standard deviation (SD), mean range (RA), mean velocity (MV), and entropy (SE). The NEO-FFI questionnaire was used to assess the Big Five personality traits, whereas the FCB-TI was used to assess temperament.

Results: One-way ANOVA revealed that the EA and CS groups were more stable in the ML direction than the FP group. In the AP direction, the athletes from the EA group were more stable than the CS group. Neither personality nor temperament differentiated the three groups of participants, apart from agreeableness, which was significantly lower in both the EA and FP groups. Openness to experience is positively associated with COP parameters, as was shown by the regression analysis. All together, COP parameters can explain for about 40% of openness variability.

Conclusions: The results of this study showed that EA and CS have better stability than footballers in both the ML and AP directions. Openness seems to be related to postural balance skills.

Background

Maintaining body equilibrium requires multiple sensory complex processes, involving coordinated actions of sensory, motor, and biomechanical systems [1]. 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 [2] and combines 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 [3]. 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 what aspects of posture best represent a set of parameters [1]. The analysis of the components contributing to postural behavior should be subject to future research about postural function [3].

Stabilographic studies indicate 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 [4]. Recent studies indicate that these differences may depend on somatic changes during the period of involution [5]. 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 examined in such sports as gymnastics [6], judo [7], rifle shooting [8], skiing [9], volleyball [10], and football [11,12]. Balance skills were explored in athletes at various levels of sports competitions [13,14]. The study showed increasing body sway in a sample of elite karate athletes, in comparison to physical education university students [15]. There is much controversy about 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 [16].

Football players must perform motor skills and control their posture during the game, while using visual information to collaborate with team members or to oppose the other team [17]. Football is a dynamic, open-minded contact sport wherein team members work together against opponents' 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, increasing the chance of players winning or performing effective defending maneuvers [18]. On the other hand, the specificity of football increases the risk of losing balance and injury [19], in particular among amateur and female football players as compared to those at a professional sports level and males [20].

Athletics' 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, 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 athletes is several times lower in comparison to football players [21], it also results in decreased performance, and prolonged absence from the sport activity [22].

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 [23] 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 [24]. Personality traits also change with age, increasing the intensity of neuroticism, extroversion, and openness to experience, while decreasing agreeableness and conscientiousness. Most studies indicate that participation in physical activity and sports is related to higher extroversion and conscientiousness, and lower levels of neuroticism [25–27]. Success in sports (and in football, in particular) is associated with higher conscientiousness and lover neuroticism [28–30]. Undergraduate athletes scored higher for extroversion, agreeableness, and conscientiousness, and lower for neuroticism, compared to nonathletes [31]. A recent study showed that Polish students of physical education (PE) scored lower for neuroticism, openness, and agreeableness than students from other faculties (a control sample) [27]. Also, team sports 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 [32]. 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) [33]. Temperament concerns emotional and stylistic characteristics of behavior, while personality is based on the self-concept and greater interaction with the environment [34]. Because temperamental traits emerge earlier in life than personality, they can directly and strongly influence the development of personality traits [33]. Research found that women scored higher than men in ER, PE, and SS, but lower in BR, EN, and AC [35]. The association between temperament and age is curvilinear and U-shaped for ER, PE, and AC, and inverted U-shaped for EN, SS, and BR [35]. Athletes usually demonstrate a low level of ER and high levels of AC and EN [36–38]. Also, a positive association was found between the activity facet trait of extroversion and physical activity in a meta-analytic review [25,39]. Apart from AC, temperamental traits seem not to be strongly related to physical activity, since research showed ambiguous connections in particular studies [40–42].

Purpose

Athletes experience numerous injuries [43,44], which can be related to poor balance skills [45] as well as to select psychological factors [46–48]. 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 [48]. On the other hand, 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 in 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 are promising and seem to confirm these assumptions. It was found that personality and temperament may be related to balance skills [11,12]. However, research on the relationship between personality and balance is scarce. This study aims 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 will be examined as well. Demographic variables, like gender and age, will be controlled in this study.

Hypotheses

On the basis of previous research [49,50], it is hypothesized that elite sports athletes will differ in postural balance from football players and also from the control group of nonathletes. Overall, athletes and football players should demonstrate better balance skills than the control sample [51,52]. Consistent with previous studies, we also assume that postural balance is related to conscientiousness as a personality trait [11] and sensory sensitivity as a temperament trait [12].

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 will compare two samples of adult athletes at various levels of sports competitions (world versus regional championships), with a group of nonathletes as a control sample. We assume that sports training differs in intensity, frequency, and strength depending on the level, which may affect group differences in balance skills. We assume that the differences in sporting level will be 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 were undergraduate students of 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 no 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 Spala, Poland.

Before the test, the participants were familiar with the information about the study, including the purpose, methodology, and procedures. In order 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, with their eyes open, and 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 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, aged between 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, while 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 and women in each group was 12:5 in the EA group, 22:10 in the FP sample, and 9:15 among controls, respectively. The demographic data, such as age, height, and weight of particular samples, are included in Table 1.

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 [53,54]. 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 [23], as well as in the Polish version of the questionnaire [24], 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 alpha 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), developed by Strelau [55,56]. Each of the six scales (Activity, Briskness, Emotional Reactivity, Endurance, Perseveration, and Sensory Sensitivity) comprises 20 items, requiring "yes" or "no" answers. The FCB-TI in the Polish version [35] 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) equals 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

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. Furthermore, two-way repeated measures ANOVA was conducted to examine sex and group (elite athletes, football players, control sample) differences in postural balance. The particular COP parameters were considered as a dependent variable, and group and sex were considered as factors. "Repeated measures" refers to the conditions eyes open and eyes closed in each COP parameter. A two-way ANOVA was also performed to examine sex and group differences in temperamental and personality traits. 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 EO condition in the ML and AP planes, respectively. The two other models concern the EC condition in the ML and AP planes. The first stage of the regression analysis included demographic variables (group, gender, and age), while the second stage included four COP parameters (SD, RA, MV, and SE) in each subsequent model.

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). All statistical analyses were performed using STATISTICA 13.1 software. We assumed an acceptable level of significance at the p 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 a dependent variable and group (EA, FB, and CS) as an independent variable. Numerous group differences in postural balance were found, as shown in Table 3. Among 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.

A series of two-way repeated measures ANOVA were conducted for COP parameters (SD, RA, MV, and SE) in both the ML and AP planes. Repeated measures regards the two conditions of eyes open and eyes closed, while the factors were group and sex. The results are given in Table S1. There were statistically significant differences between group means in the ML plane for SD, RA, and SE, and for SE in the AP plane. Furthermore, statistically significant differences were found between conditions EO and EC for SD and MV in both the ML and AP planes, and also for RA in the AP plane and SE in the ML plane. An interaction effect between group and conditions was present for SE in the ML plane. Consistent with the hypothesis, there were no sex differences in balance skills.

A series of two-way ANOVA tests were performed for particular temperamental traits as dependent variables, with the two factors group and sex as independent variables (Table S2). A group difference was found solely for endurance. The post hoc comparison showed that the sample of football players scored significantly lower in endurance than both elite athletes and controls ($p < 0.05$). There was no statistically significant difference in terms of sex, and no interaction between group and gender.

There were no statistically significant differences between group means (EA, FP, CS) in personality traits, as determined by two-way ANOVA (Table S3). Gender differences were found for openness ($p < 0.05$) and agreeableness ($p < 0.01$), with women scoring significantly higher than men. No interaction effect was noted between group and gender in terms of personality.

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

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 such predictors as demographic variables (group, sex, and age), and COP parameters (SD, RA, MV, and SE) in both EO and EC conditions, and also 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). The results of the regression analyses are presented in Tables S4–14. Most of the regression models have failed, demonstrating poor R^2 and F-tests of overall significance, with insufficient p-values. One can conclude that these regression models do not fit the data, so 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 in the ML plane and EO condition. Model 1 in the second step of the regression analysis explained 20% of the ER variance, $R^2 = 0.20$, $R^2_{adj.} = 0.11$, $\Delta R^2 = 0.14$, $F(7,65) = 2.29$, $p < 0.05$ (see Table S9 for more details). 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 such COP parameters in the ML plane and EO condition 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 openness variance, $R^2 = 0.35$, $R^2_{adj.} = 0.28$, $\Delta R^2 = 0.25$, $F(7,65) = 5.08$, $p < 0.001$ (see Table S12 for more details). Also, agreeableness was solely associated with gender (Table S13). The agreeableness explained by sex and the set of variables in particular regression models ranges from 19% to 23%.

Discussion

Group differences in postural balance skills

The present study indicates that there are significant differences in the COP parameters between the three following samples: athletes (EA), football players (FP), and 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 also in the AE group as compared to FP. However, in the AP direction, the FP showed a higher speed of body sway than persons 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, as compared to FP. This may indicate a specific adaptation of posture control among FP, developing 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 also showed a greater dependence of posture control on eyesight in elite track and field athletes and football players than in the control group (CS) [57].

Consistent with previous research [4], balance skills are not related to gender. Body posture control is an individual feature depending on body build, age, and level of training. Numerous studies show that balance-oriented exercises can improve adaptive posture control and that, the higher the level of competition, the more stable the posture in soccer [13,17,50,58]. 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 [59]. 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 [60].

COP parameter values testify to global coordination abilities concerning the equilibrium system [61]. Higher COP variability may indicate various regulatory mechanisms manifesting in the ability to maintain balance by triggering random movements. The test results of Yamada et al. [62] indicated that, in football players, along with the increase in sports advancement, the instability in the AP plane increases. Other studies [63] indicate that specific training contributes to a decrease in the variability of body excretions. COP parameter values testify to global coordination abilities being related to the equilibrium system [61]. Higher COP variability may indicate various regulatory mechanisms, manifesting in the ability to maintain balance by triggering random movements.

Our findings differ from Biec and Kuczyński [16], who stated that footballers have better body balance control compared to nonathletes. 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. [12]. The other studies indicate that football players and gymnasts are not very different in terms of static or dynamic control [64].

Group differences in personality and temperament

Surprisingly, neither personality nor temperament traits differ 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 [27] 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. This study seems partially consistent since agreeableness was significantly lower in both EA and FP samples when compared to the CS group (which includes physiotherapy students). The other study [65] compared personality traits between individual and team sport athletes. 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 for neuroticism, extraversion, conscientiousness, and openness. On the other hand, Talyabee et al. [31] 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 [25] indicates that sport participants with high levels of agreeableness report more favorable relationships with their teammates and coaches. Highly agreeable athletes also demonstrate less team-related conflict and better cooperation and relationships with other team members [66]. The role in the team (i.e., leader, star) may also determine the usefulness of higher or lower agreeableness, as Kim et al. indicated [67]. It should be said that high inconsistency exists between studies, which may be determined by cultural differences, or maybe the specific sport discipline.

Nevertheless, the present study indicates that an essential trait that differs from physical education students from professional athletes is agreeableness. People who score high on agreeableness are perceived as empathetic and altruistic, while a low agreeableness score relates to selfish behavior and a tendency to compete with others rather than cooperate [68]. Because sporting is fundamentally related to competition, a lower level of agreeableness may be a beneficial trait in sports achievement [69]. Thus, lower agreeableness may be related to frequent participation in competitions, a high level of aspiration, and a need for achievement.

However, it is important to note that the above interpretation may be false, since 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. In the CS women dominated, and scored higher on agreeableness in this study. Furthermore, gender was a significant predictor of agreeableness, explaining approximately 20% of its variance. Moreover, gender differences were found in openness to experience. The higher levels of agreeableness and openness among women, when compared to men, are consistent with previous studies about individual differences in personality [23,24]. On the other hand, the present study did not find significant sex differences for neuroticism, extroversion, and conscientiousness, as well as for all temperamental traits, which is not consistent with previously reported studies [23,24,35]. 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 endurance as a temperamental trait than 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 the previous study, which did not show any significant differences between team and individual sports in terms of temperamental traits [70]. 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, so it may be a random effect of a 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 was found between select COP parameters and traits of personality and temperament, the associations were weak in the present 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 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 emotional reactivity 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, when compared to highly ER individuals [33]. 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 [70]. ER was found to be an essential trait for predicting physical activity and high sports achievement [36,37,71,72]. Emotional reactivity facilitates quick reactions to emotional stimuli and heightened emotional sensitivity and intensity [73]. The present study indicates 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 highly emotionally reactive 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 plane, 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 [74]. Research indicates that openness is related to physiological responses to chronic social stress [75]. Herzhoff and Tackett [76] found three facets of openness in children: intellect, imagination, and sensitivity. 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 [23]. Conversely, low openness to experience was found as a preclinical marker of incipient cognitive decline in older adults [77]. Intelligence has a strong genetic basis and manifests at the neuronal level in a shorter time and with a more accurate response for stimulus. Thus, openness and balance share a common neuronal mechanism responsible for adaptation to the environment. This needs to be tested in future research, since COP parameters may explain 35% of openness variance.

It is important to note that the nervous system is much more involved in the control of the position of the body in the ML plane in comparison to the AP plane. Control of the human body posture is characterized by greater stability in the AP plane, because of two-legged support of the body in vertical standing. Furthermore, research showed that conscious control of the body posture is less effective than the automatic [78–80]. 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 value of both parameters may indicate better stability. On the other hand, lower values of mean velocity (MV) indicate a certain calm control [3]. 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 through decreasing SD and MV.

On the other hand, highly emotionally reactive 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 emotional reactivity was found to be associated with higher-order flexibility and cognitive control [81], more successful self-control [82], high energetic arousal and hedonic tone of arousal, and also low tense arousal [83]. Conversely, highly ER people seem to present higher emotional tension and cognitive stiffness.

The present study is not consistent with previous research. Wojciechowska- Maszkowska et al. [12] found a relationship between body balance and conscientiousness among football players. SD, AP, 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 [11]. 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 are some limitations of the 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. Secondly, 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 may include other sports disciplines. Finally, personality and temperament traits were measured using a self-reported survey. The other experimental methods for assessing behavior concerning personality and temperament traits may be taken into consideration in future research.

Conclusions

The results of this study indicate that people from the EA and CS groups were more stable in the ML direction than 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. To sum up, 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 seem to be the only two traits that are associated with such coordination skills as maintaining equilibrium on the stabilographic platform. Our results indicate that people with heightened ER cope with body sway in the ML plane using an opposite strategy to people with high scores in openness when all sensory systems are available (eyes open). It seems that the inclusion of such components as personality and temperament in the assessment of posture control may enrich our knowledge of adaptive behavior. Sports psychologists and trainers might use the results of the present 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.

Declarations

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Suplementary materials

Additional file 1: Table S1-S14.

Declarations

Ethics approval and consent to participate

The protocol and consent forms were approved by the Bioethics Committee of the District Medical Chamber in Opole (Resolution No. 151), in conformity with principles identified in the Declaration of Helsinki. All participants provided written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The data supporting the findings can be found at Mendeley Data, http://dx.doi.org/10.17632/pnc5kkv876.1/

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Author's contributions

B.W-M., D.B. and A.R. conceived and designed the experiments. A.R. performed the data analysis. B.W-M., D.B. and A.R. prepared the original manuscript. All authors contributed to the data collection and interpreted the experimental results. All authors edited and revised the manuscript, and have read the final version of the manuscript.

Abbreviations

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.

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Tables

Table 1. Demographic data in the particular groups of participants

Demgrapic variables	Control Sample		Elite Athletes		Futball 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
Hight [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

Table 2. Descriptive statistics for the total sample

Variables	Range		*M*	95% *CI*		*SD*	*SE*
	Min.	Max.		*UP*	*LL*		
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.

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

Variables	EA (n = 17)		FP (n = 32)		CS (n = 24)				
	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	

Note. 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.

Table 4. Correlation between COP parameters with 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 with 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. $p^* < .05$.

Supplementary Files

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- SupplementaryMaterials.docx