

Effects of a slow-paced breathing (SPB) intervention on young athletes' psychological adjustment: A study with female volleyball players

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Abstract

Adolescence is a transitional period characterized by personal, academic, and social pressures. Girls, in particular, are more reactive towards stressful events, leading to an increased prevalence of internalized mental disorders. Therefore, the present study was intended to explore slow-paced breathing as a mental health and well-being promoting tool for young female volleyball players, while considering its feasibility in an organized sports setting. Twenty-two athletes ranging in age from 15 to 17 years ($M = 15.86$, $SD = .83$) from the under-16 and under-17 teams in the same volleyball club were assigned to the experimental (EG) and control group (CG). The EG performed an 8-week, 5-min, guided slow-paced breathing protocol, whereas the CG ($n = 12$) followed an extended warm-up routine conducted by a coach while the breathing session was taking place. Pre- and post-intervention questionnaires with self-report measures of trait anxiety, perceived stress, positive and negative affect, subjective happiness, life satisfaction and perceived performance were administered, coupled with weekly measurements consisting of a CO₂ tolerance test. Results suggested that, except for positive affect, all psychological and well-being markers showed no significant differences when compared to the control group after the intervention, as well as when comparing pre- and post-intervention periods within the EG. Nevertheless, overwhelmingly positive qualitative reports and significant improvements in CO₂ tolerance may imply that some effects of the slow-paced breathing intervention took place in relation with the short session duration and/or intervention length. Future studies should further explore simple, accessible interventions such as this one to address the onset of mental disorders and/or daily stress in a sports setting.

Keywords: young athletes; adolescents' well-being; female sports; mental health; anxiety management.

Introduction

Mental health is more than the absence of mental illness and/or its symptoms. It is essential for overall well-being, ability to face stress, everyday resilience, social and community involvement, as well as society's economic development (Palha & Palha, 2016; Zulaika Abdul Ghani et al., 2021). Adolescence is a particularly stressful transitional period characterized by underlining personal, academic, and social pressures which enhance the potential for on-set mental disorders (Acharya et al., 2018). In most cases, mental disorders first occur between adolescence and early-adulthood (Caspi et al., 2020) and account for nearly half of the burden of disease between the ages of 10 through 24 years (Mei et al., 2020). Mental health concerns, such as depression (Acharya et al., 2018), anxiety disorders (Strawn et al., 2021), suicide (Smolianov et al., 2020), substance abuse (Richert et al., 2020), and eating disorders (Valentin Ayala, 2020) have increased significantly among adolescents in recent years. Moreover, the aforementioned mental health concerns have been shown to severely affect adolescents' overall well-being, happiness, inter-personal relationships, and physical health, as well as to enhance the risk of aggravation, or at least persistence, of mental health disorders in adulthood (Arslan, 2021; Caspi et al., 2020). Therefore, early onset prevention and/or treatment appear to be of the utmost importance, especially for adolescent girls. Compared to their male peers, females experience considerably higher levels of depression and anxiety, wherein adolescence appears to be the turning point. Puberty timing and possibly menstruation related with hormonal fluxes may be responsible for this gender differences (Byrne et al., 2022; Owens et al., 2020).

Furthermore, physical activity and sport participation could have a positive impact in adolescents' mental health (Vynogradskyi et al., 2017). Indeed, Halliday and colleagues (2019) suggested that differences in sport and physical activity engagement could explain mental health gender differences in adolescents. However, organized sports present specific additional stressors, including overtraining, perfectionism, overloaded schedule, performance anxiety, and the competitive environment (Campbell et al., 2018; Souza Zanini et al., 2018), in addition to the stressors that their non-athletic peers experience (Xanthopoulos et al., 2020). Due to these unique conditions, finding tools to address mental health and well-being early in youth female athletes is essential to avoid both onset and future concerns.

Slow-paced breathing (SPB) entails a non-invasive and highly accessible practice, which is often recommended for stress reduction and improving overall well-being. Its origins come from different cultures and traditional practises, such as pranayama and meditation (Edwards, 2008), and are often incorporated with cognitive behavioural and mindfulness-based therapies (Brenner et al., 2020; Newman et al., 2020). Most breathing techniques aim to slow the breathing rate to around six breaths per minute (bpm), as spontaneous breathing rates hover around 12-20 bpm (Borges et al., 2021). Considering its mechanism of action, although not entirely understood, SPB is suggested to elicit a sympathetic to parasympathetic nervous system shift via vagus nerve activation (Gerritsen & Band, 2018).

Recent research in this field has shown positive effects on both psychological (e.g., stress, anxiety, depression) (Erkkilä et al., 2021; Jerath et al., 2015; Ma et al., 2017) and physiological health (e.g., HRV, cardiac vagal activity, blood pressure) (Laborde et al., 2021). In youth, it has been shown to significantly reduce state and trait anxiety and other mood disorders, including depression (Aranberri-Ruiz et al., 2022; Sellakumar, 2015; Laborde et al., 2017). Particularly in athletes, youth or otherwise, similar interventions suggested that slow breathing rate could improve stress management (Hunt et al., 2018), emotional well-being (Borges et al., 2021), sleep quality (Laborde et al., 2019), academic achievement (Firth-Clark et al., 2019) and lead to decreases in pre-test and overall trait anxiety (Deschodt-Arsac et al., 2018; Dziembowska et al., 2016).

Thus, the present study aimed to explore SPB as tool for improving various psychological and well-being markers in young volleyball players. Feasibility and participant's adherence to the intervention also present major goals considering the acknowledged time constraints in organized sports. As an additional goal, we also intended to explore the participants' beliefs about the impact of psychology in athletes' daily life and/or sporting career.

Material and methods

Participants

Twenty-six female volleyball players were recruited to take part in the present study. However, four participants (15.38%) were excluded due to their unavailability to complete the intervention for personal reasons. The final sample included 22 athletes ranging in age from 15 to 17 years ($M = 15.86$, $SD = .83$). Participants' average of weekly practice hours in the present year was 7.00 ($SD = 1.35$) and the average years of practice was 5.95 years ($SD = 2.89$). Only one participant (4.5%) had previous experience with a sports psychologist.

Measures

To assess the efficacy of the breathing protocol, psychological measures in the form of questionnaires and a physiological measure in the form of a stress tolerance test were applied. The questionnaires were employed at baseline and follow-up to compare participants' overall psychological health and well-being pre- and post-intervention, whereas the stress tolerance test was conducted weekly to access the progression during the intervention period.

Self-report measures

Psychological measures included trait anxiety and perceived stress and were measured by the Portuguese versions of the State-Trait Anxiety Inventory (STAI Form Y-2) and the Perceived Stress Scale (PSS-10), respectively. The STAI Form Y-2 was first developed by Spielberger et al. (1982) and adapted to Portuguese by Silva and Campos (1998). It comprises 20 items answered on a 4-point Likert scale ranging from 1 (*Almost never*) to 4 (*Almost always*). Scores range from 20 to 80, with higher scores indicating greater levels of anxiety. The PSS-10 was first developed by Cohen et al. (1983) and adapted to the Portuguese language by Trigo and colleagues (2010) and comprises 10 items answered on a 5-point Likert scale ranging from 1 (*Never*) to 5 (*Very frequently*). Scores range from 10 to 50, with higher scores representing greater levels of perceived stress.

Emotional and subjective well-being were assessed using the Positive and Negative Affect Schedule (PANAS), the Satisfaction with Life Scale (SWLS) and the Subjective Happiness Scale (SHS). The PANAS was first developed by Watson et al. (1988) and comprises 20 items answered on a 5-point Likert scale ranging from 1 (*I'm nothing like that*) to 5 (*I'm always like that*), aiming to measure the experience of positive and negative affect. The Portuguese version showed appropriate reliability (Galinha & Pais-Ribeiro, 2005). The SWLS was first developed by Diener et al. (1985) and then adapted to Portuguese by Corte-Real and colleagues (2004), including 5 items answered on a 7-point Likert scale ranging from 1 (*strongly disagree*) and 7 (*Strongly agree*). Scores range from 5 to 35. The SHS was first developed by Lyubomirsky and Lepper (1999) adapted to the Portuguese language by Spagnoli and colleagues (2012). It comprises four items answered on a 7-point Likert scale ranging from 1 (*Totally disagree*) to 7 (*Totally agree*). Score ranged from 1 to 7. Higher scores in both SWLS and SHS reflect greater subjective well-being. In addition, a perceived performance (PP) item developed by Arnold et al. (2018), answered on a 10-point scale, was implemented to access subjective sports performance.

In order to understand the participants' opinion and past experiences with psychological interventions, as well as their beliefs about the impact of psychology on athletes' daily life and/or sporting career before the intervention, four additional items were included in the pre-intervention questionnaire for both groups. Three items (e.g., "Do you think psychological factors can have a determinant role in athletes' life satisfaction and quality?") were answered on a 7-point Likert scale ranging from 1 (*Not important*) to 7 (*Totally important*).

These items were followed by a non-obligatory open answer item “Generally, what is your opinion about sports’ psychology interventions?”.

In the EG’s, a second questionnaire with an additional set of seven items was added to access overall perceptions and attitudes towards the intervention, as well as its feasibility, and peer recommendation. Items such as “I’ve noted positive changes resulting from the intervention.” and “The protocol was useful and easy to apply on a daily basis.” were answered on a 4-point Likert scale ranging from 1 (*Strongly disagree*) to 4 (*Strongly agree*). Similarly, these items were followed by a non-obligatory open answered item “What did you think about this intervention, did it impact your day-to-day? How?”.

Physiological measures

Physiological measures were used to assess psychological health in the form of stress tolerance, specifically tolerance to endogenous CO₂. The relationship between endogenous CO₂, and tolerance to both stress and anxiety is identified in the literature (Rappaport et al., 2017). Emotional distress and anxiety often elicit hyperventilation, which in turn results in respiratory alkalosis, as shown by a decrease of CO₂ concentration at the end of the exhale portion of the breath (Henje Blom et al., 2014). Thus, a similar measure of the CO₂ tolerance test (CO₂TT), as applied by Bentley et al. (2020, 2022), was used. Simply, the CO₂TT involves a timed maximal-duration expiration, in which higher scores, measured in seconds, are associated with greater levels of physiological stress tolerance. Participants were first introduced to the test prior to the intervention, to control for possible improvements associated with test learning.

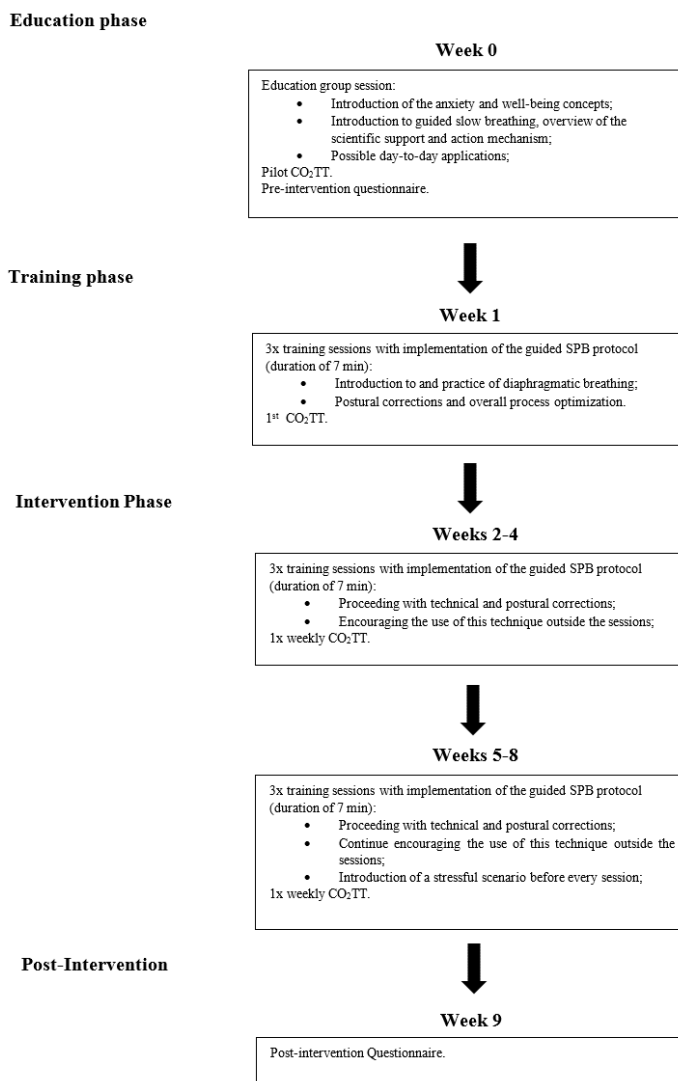
Study design and procedures

The present study was carried out using a quasi-experimental non-equivalent group design. Under-16 and Under-17 teams from the same volleyball club were assigned to the experimental (EG) and control group (CG), respectively. EG ($n = 10$) performed an 8-week slow guided-paced diaphragmatic breathing protocol, whereas CG ($n = 12$) followed an extended warm-up routine conducted by a coach while the SPB session was taking place. The intervention followed the guidelines developed by Cruz and Viana (1996) for sports skill training. Prior to the intervention, a session was conducted by the main researcher with the EG, addressing the concepts of psychological health, anxiety and well-being, as well as introducing guided slow breathing as a managing tool and providing real life examples of these techniques. A pre-intervention questionnaire was applied in both groups during this period. During the 8-week intervention period, the EG performed a group 5-min breathing session three times per week at the beginning of practice, to avoid their urge to leave and possible mental and/or physical fatigue. After the second weekly session, a physiological state measure of stress tolerance was applied in the form of a CO₂ tolerance test, which had been tested during the first sessions. Post-intervention questionnaires were applied in the one-week follow-up period. Both pre- and post-intervention questionnaires were applied in the presence of the researcher during a team’s practice session. Figure 1 shows the full details of the intervention. Written consent for the participation in the study was signed by all twenty-two athletes and one of their respective parents or guardian/s. The study was conducted following the Declaration of Helsinki and was approved by the Ethics committee of the Portuguese Faculty of Sports of the University of Porto (Project identification code CEFAD 10 2022).

Intervention program and protocol

This slow guided breathing protocol was based on two similar interventions conducted on a high school setting by Bentley et al. (2020, 2022). However, the application to a youth sport setting involved minor adjustments. Thus, the application of a state psychological measure and presenting educational videos in the beginning of each session were abandoned for practical reasons.

The intervention consisted of a 5-minute slow guided-paced nasal breathing exercise. Different time length protocols have shown positive results in anxiety, depression, and well-being in both adult and adolescent population (e.g., Kenttä et al., 2019; Zaccaro et al., 2018). A 5-minute protocol was chosen due to the usual time constraints in a sports practice setting. Even though coaches often acknowledge the importance of the psychological dimension of sports, training routines do not reflect it (Barker & Winter, 2014). A short session duration could be more appealing, considering it does not “steal” much time from other practice components. Moreover, the main characteristics of the protocol were a 6-bpm frequency, an inspiration-expiration rate of 4:6, and being strictly nasal diaphragmatic breathing. Lower breathing frequencies, particularly 6-bpm, are recognised as the benchmark in heart rate variability (HRV) training (Sevoz-Couche & Laborde, 2022), and thus its benefits on psychological health and well-being are well documented (Schwerdtfeger et al., 2020). Additionally, another common characteristic of multiple breathing techniques, included in HRV training, yogic breathing, and meditation, is a prolonged expiration (Komori, 2018). By further enhancing vagal tone, promoting the shift to a parasympathetic, state prolonged expiration has been shown to promote relaxation, decrease anxiety, and improve overall well-being (Komori, 2018; Ovadia-Blechman et al., 2022). Lastly, diaphragmatic breathing is synonymous with most breathing techniques. It involves contraction of the diaphragm, expansion of the stomach and accentuation of inspiration and expiration, automatically decreasing breathing frequency and maximizing blood gases concentration (Ma et al., 2017). Furthermore, most slow breathing techniques are performed via nasal respiration and nasal stimulation. In animal models, nasal breathing has been shown to regulate brain and autonomic system activity via receptors in the superior nasal meatus, which in turn may influence psychological and/or behavioural outputs (Zaccaro et al., 2018).

**Figure I.**

Summary of the 8-week SPB Intervention Plan.

A usual session occurred in the beginning of practice, prior to the team's warm-up, in the athletes' changing room. It begun with a breathing warm-up, consisting of three self-regulated slow breath cycles, and followed by the paced 6 bpm breathing exercise for 5 minutes. The SPB exercise was guided by the team's coach, also the main researcher of the study, who had experience in similar breathing practices. Instructions to "inhale" and "exhale" were provided while the athletes were in a seated position with closed eyes and hands on their stomach to get feedback on their diaphragmatic breathing. At the intervention's midpoint period, stressful scenarios were described while the group performed the breathing warm-up. The scenarios fell in three categories: school related (e.g., "I will do a presentation alone in front of the class"); volleyball related (e.g., "First time a relative/friend comes to a game and has high expectations."); social life related (e.g., "I find myself alone with a group of unknown people").

Statistical analysis

Data was analysed using IBM SPSS statistics 28.0 and GraphPad Prism 9.4.1. As preliminary analyses suggested violations of the normality assumption, nonparametric tests were applied. Comparison between groups at pre- and post-intervention was carried out with Mann-Whitney test. Wilcoxon sign ranked test was performed to identify differences between pre- and post-intervention in the EG. Lastly, for pairwise weekly comparison of the CO₂TT scores, a Friedman test with post-hoc Dunn's test was conducted. Open-ended questions were analysed qualitatively through content analysis (Vaismoradi et al., 2013). Following a deductive approach, a coding protocol was firstly developed. New categories were also included over the course of the data analysis when emerged on participant's reports.

Results

Perception of sports psychology

Prior to the intervention, most participants regarded the role of psychology in sports as mostly important. About 80-90% of the participants deemed it highly important for athlete's psychological skills ($M = 6.41$, $SD = .67$) and quality of life ($M = 6.36$, $SD = .79$). Concerning the impact on sports performance ($M = 5.23$, $SD = 1.31$), although 95% ($n = 21$) acknowledged it as important, 45% ($n = 10$) of the participants deemed it very important or totally important.

Generally, participants recognised the importance of psychology in athlete's sport careers, but also in their personal lives. Topics such as confidence ($n = 3$), time-management ($n = 1$), focus ($n = 1$), personal growth ($n = 4$), in-game self-control ($n = 2$), and overall health ($n = 2$) were addressed. As explained by one participant:

"They [psychologists] help improve the athlete's sports performance, as psychology and mental health are very important factors in one's life and for athletes it's even more valuable. If an athlete is mentally unstable, no matter their capabilities, their performance will never be excellent (...) mental health and sports performance are closely related."

Intervention effect on psychological health and well-being markers

Preliminary statistical analysis found no significative differences between the CG and EG before the intervention. Intervention's effect was measured by a mixed model comprehending a Wilcoxon signed ranked test to detect differences between the pre- and post-intervention measures in the EG, and a post-intervention comparison between experimental and CG's measures performed via Mann-Whitney test, represented on tables I and II, respectively. Regarding the Wilcoxon test, no significant differences were found between the two moments. However, regarding the differences between the CG and EG, positive affect was deemed significantly higher in the EG after the intervention by the Mann-Whitney test, $Z = -2.65$, $p = .008$, whereas the remaining variables did not show significant differences.

Table I. Differences between EG and CG's Post-Intervention Psychological Measures.

	Control		Experimental		Mann-Whitney test	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>Z</i>	<i>p</i>
Trait anxiety	45.17	11.84	41.40	14.28	-.59	.552
Perceived stress	29.75	7.71	30.50	8.36	-.43	.667
PANAS						
Positive affect	36.25	3.49	40.80	6.58	-2.65**	.008
Negative affect	28.50	5.87	28.30	10.08	-.36	.715
Satisfaction with life	23.33	8.08	27.20	5.12	-1.03	.303
Subjective happiness	3.48	0.94	3.73	0.84	-.50	.619
Perception of performance	5.83	1.03	6.20	1.99	-1.20	.228

Qualitative impact of the intervention

All participants recognised a positive impact on their daily life ($M = 3.33$, $SD = .47$), and 40% ($n = 4$) acknowledged that the group strongly felt this positive impact. Moreover, participants considered the intervention highly useful ($n = 10$), easy to apply ($n = 10$), easy to learn ($n = 10$) and would recommend a similar protocol to a family member and/or a friend ($n = 10$).

Table II. Differences between EG's Pre and Post-Intervention Psychological Measures.

	Pre (<i>n</i> = 10)		Post (<i>n</i> = 10)		Wilcoxon signed ranked test	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>Z</i>	<i>p</i>
Trait anxiety	44.10	14.50	41.40	14.28	-1.722b	.085
Perceived stress	33.00	8.93	30.50	8.36	-1.539b	.124
PANAS						
Positive affect	38.80	5.27	40.80	6.60	-1.794a	.073
Negative affect	26.80	8.94	28.30	10.08	-.896a	.370
Satisfaction with life	25.70	4.27	27.20	5.12	-1.362a	.173
Subjective happiness	3.65	0.78	3.73	0.84	-.422a	.673
Perception of performance	6.10	1.91	6.20	1.99	-.447a	.655

Note. a. based on negative ranks; b. based on positive ranks.

Overall, participants described themselves as more relaxed ($n = 7$), more positive ($n = 3$), and more capable of dealing with stressful situations ($n = 5$), both in sports, but mostly in daily life.

"I really felt that this protocol helped me feel more positive towards my day-to-day and the way I face it. (...) I was able to remain in control even in uncomfortable situations. I feel better, happier, and more at peace with life."

CO₂ tolerance test

Results of the weekly pairwise comparison of scores of the CO₂TT through Friedman test are represented in figure II. Significant effects of the intervention weekly development on CO₂TT were identified, $\chi^2(7, n = 10) = 55.70, p < .001$. Post-hoc Dunn's multiple comparison test identified significant differences between week 1 median score and weeks 4-8, between week 2 and weeks 6-8, and between week 3 and week 8. The significant increase in median CO₂TT scores in the latter weeks, compared to the first, imply an increase in tolerance of endogenous CO₂ through the course of the intervention.

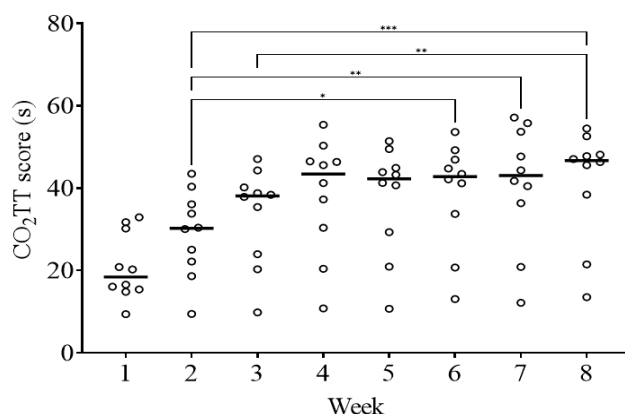


Figure II. EG's CO₂TT scores: weekly pairwise comparison.

Note. Each symbol represents an individual's CO₂TT score within each week. The horizontal line represents the group median. * $p < .05$, ** $p < .01$, *** $p < .001$; Comparisons between week 1 and the rest were eliminated to

Discussion

The aim of the present study was to explore the impact of a SPB intervention on youth female athletes' mental health and well-being, as well as the feasibility and adherence to a slow guided breathing protocol in a youth sport setting. Although most measures did not reveal significant differences between the EG and CG, positive affect was higher in the EG. Furthermore, no significant differences were found in the psychological mental health and well-being markers between the pre- and post-intervention periods in the EG.

Findings of the present study, particularly psychological measures, are not consistent with the stress-, anxiety-reducing, and well-being promoting capacities reported in recent research on SPB and similar techniques (Laborde et al., 2022; Lehrer et al., 2020). In effect, even though both anxiety and perceived stress decreased following the intervention, a statistically significant positive impact on both anxiety and stress was expected (Jerath et al., 2015; Ma et al., 2017). The same was the case for the well-being markers (Peterson et al., 2017).

Various factors could be responsible for the intervention's lack of statistical effect. The reduced breathing exercise duration of 5-min and/or relatively small number of sessions could not be enough for the physiological effects to take place. In fact, while You and colleagues (2021) found no differences between 5-, 10-, 15- and 20-minutes exercise duration in cardiac vagal activity, differences in psychological measures were not addressed both during an immediately after the session. Additionally, the effect of SPB on cardiac vagal activity is short-lived, with levels returning to normal almost immediately after exercise cessation (Laborde et al., 2022). Contrariwise, Laborde and colleagues (2019) have shown chronic increases in cardiac vagal activity in a long-term intervention at 6 bpm (15 min/day for 30 days), almost 4 times the amount of the total minutes in the present study's intervention. In addition, the age of the intervention group, composed by adolescents, presents a challenge to the concentration this type of exercise requires (Tan, 2016). Perhaps reduced session duration did not allow participants to fully engage with the breathing exercise until its latter stages, leaving little time for its effects to take place. A similar intervention by Bentley and colleagues (2022), where the participants performed 5 min sessions 3 times a week for 5 weeks in a group setting also reported non-significant differences in trait anxiety, both for self-paced and guided-paced slow breathing groups.

Nevertheless, most of the participants of the SPB group described themselves as more relaxed, capable of managing stress, and reported a shift towards a more positive mindset. Participants also found the protocol easy to learn and apply, reported a strong positive impact in their daily life and would recommend similar interventions. Likewise, significant improvements in the weekly CO₂TT imply that stress tolerance was improved. Studies in children and adolescents have shown a consistent link between CO₂ hypersensitivity and both anxiety and panic disorder (Pine et al., 2005). Equally, a study by Henje Blom and colleagues (2014) identified increased respiration rate and lower concentration of end-tidal CO₂ in adolescent girls with emotional disorders, compared with their healthy control peers. Thus, considering the significant differences between groups in positive affect following the present intervention, coupled with decreases in trait anxiety and perceived stress, findings could imply that some effects were taking place even with the short duration sessions.

Conclusions

Given the current scenario of youth's mental health, recently heightened due to the COVID-19 pandemic, accessible tools for anxiety and stress management become of the utmost importance. Focusing on the youth female athlete population, with its unique subset of problems and stressors, the present study explored the incorporation of SPB within sport practice. The feasibility of the protocol, its effects on several psychological health and well-being markers, and in physiological stress tolerance provided insights for further research in the field, as well as further similar applications.

Nevertheless, the small sample size, exacerbated by four waivers in the EG, could have negatively impacted the statistical analysis (Hackshaw, 2008). Future studies should endeavour to replicate this protocol in a larger sample size, which may identify significant effects of this SPB intervention. Moreover, considering its close relationship with SPB, physiological measures, specifically measuring the cardiac vagal tone through HRV, could have enriched the study's results (You et al., 2021). Besides, measuring HRV would give immediate feedback, during the session, about the presence of physical effects associated with the SPB (Sevoz-Couche & Laborde, 2022). In summary, future studies in the athletic setting should increase session duration and/or intervention time, and increase sample size, as well as measure HRV.

Conflict of interest - The authors declare no conflict of interest.

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