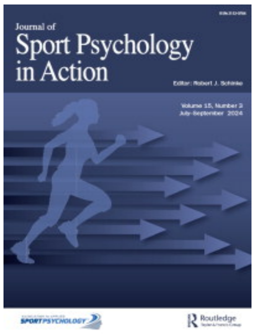

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A Smartphone Enabled Slow-Paced Breathing Intervention in Dual Career Athletes

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ABSTRACT
Dual career athletes are exposed to many stressors, for example, balancing deadlines with competition schedules. Slow-paced breathing (SPB) is an accessible relaxation technique, which can be practiced via smartphone applications, however delivery through applications has limited exploration. We discuss a four-week intervention delivered to dual career athletes which included screening stress and wellbeing, and a focus group discussion to capture athlete reflections on the SPB intervention. Athletes reported SPB reduced pre-performance anxiety, increased focus during performance, and increased relaxation before sleep. Findings suggest SPB is successfully delivered via smartphones, positively influences stress management, sleep and performance, and may be a simple tool for practitioners and athletes to utilize.

KEYWORDS
Diaphragmatic breathing; heart rate variability; relaxation; stress management; wellbeing

Introduction

Student athletes are exposed to many stressors across their university career and must co-manage academic study and athletic pursuits; often these athletes are termed "dual career athletes". They face many demands within elite sport and education making this pathway potentially challenging and stressful. The balance of dual demands can result in fatigue, a decrease in motivation, limited life experience outside of sport and education, increased overload, and increased injury risk (McCormack & Walseth, 2013). Richartz and Sallen (2017) found that elite dual career athletes show high indicators of stress. A stressor could

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include for example, balancing deadlines with competition schedules. Therefore, interventions aimed at reducing stress, improving wellbeing and coping resources may be of benefit to dual career athletes. The current study aims to investigate the effectiveness and athlete perceptions of one easy to administer and accessible relaxation technique (slow-paced breathing, SPB) in this context.

Breathing techniques are recognized as an effective stress management technique for athletes (e.g. Conlon et al., 2022). Beneficial effects are attributed to the influence of SPB on the autonomic nervous system (ANS), which is involved in the adaptation to stress (Porges, 1992). More specifically, SPB increases activity within the parasympathetic branch of the ANS by stimulating the vagus nerve, which is then reflected in increases in vagally-mediated heart rate variability (vmHRV) (e.g. Laborde, Allen, et al., 2022). vmHRV is of great importance in sport psychology due to the role it plays in many self-regulatory phenomena such as anxiety management (Laborde et al., 2018; Mosley & Laborde, 2022). More specifically, higher vmHRV can indicate both mental and physical wellbeing (Kemp & Quintana, 2013). This is of interest in the dual career athlete population who may have reduced wellbeing due to increased demands and subsequently lower vmHRV.

Previous interventions of this nature often use a training protocol based on HRV biofeedback which has been shown to improve psychological state and performance within sport (e.g. Pagaduan et al., 2022). HRV biofeedback refers to SPB realized while visualizing a heart rate, HRV, and/or respiratory signal (Laborde, Allen, et al., 2021). It is usually implemented as a multi-session training protocol, following (in some cases) an introductory session aimed to determine the resonance frequency (i.e., the breathing frequency triggering the highest cardiovascular resonance, associated to enhanced physiological outcomes) (Lehrer et al., 2013; Shaffer & Meehan, 2020). However, HRV biofeedback multi-session training protocols can be time consuming. In addition, previous studies showed that there were no differences in vmHRV increases during and decreases after SPB with and without biofeedback (Laborde, Allen, et al., 2021). Smartphone applications to assist SPB (without biofeedback) have yielded increases in resting vmHRV (Laborde et al., 2019), and have been explored as an avenue to make mental skills training more accessible to athletes (Rist & Pearce, 2017). However, it has been shown that athlete engagement drops over time (Rist & Pearce, 2017). Therefore, it is important to understand how to retain athlete engagement in app-based training. It has been suggested that relaxation techniques, including SPB, may be more successful if paired with psychoeducation (Shah et al., 2014). Within clinical populations, for example those with mental disorders, combining psychoeducation and relaxation techniques mitigated depression and stress, increased knowledge on stress management and increased relaxation intensity (Shah et al., 2014). Combining these may increase retention of knowledge and skills, which could help improve intervention success (Shah et al., 2014).

There is limited multi-session SPB research involving athletic populations and assessments relating to the fidelity of such interventions are lacking. The use of smartphone applications and psychoeducation to develop SPB is an area worthy of investigation, given it is easy to use/deliver, cheap and can be easily embedded into athletes' daily routines. Due to previous research observing drop offs in app engagement and limited explorations of how athletes might use SPB in their daily routines, the perceptions of the intervention is also of great interest. Therefore, the aim of this paper is to investigate the effectiveness and perceptions of a psychoeducation and smartphone enabled SPB intervention for dual career athletes.

Context

The lead author is accredited by the British Association for Sport and Exercise Science (BASES) as a chartered sport and exercise scientist (CSci) and specializes in HRV research; adopting a psychophysiological approach to applied research. This approach has developed from the pursuit of a PhD within the field of vmHRV and through conducting research with athletes who were interested in the implications of psychophysiological functions and performance. Breathing research and its application naturally followed this given the positive effects SPB has on vmHRV. Being able to show athletes what is happening to their psychophysiological state through a simple breathing technique sparked the interest of the researcher and athletes alike. Given the lead author is predominantly research-based, it is important to collaborate with practitioners working in the field to ensure applied research is carried out effectively. The lead author has experience in conducting research with elite level athletes and co-delivering interventions alongside other practitioners (Mosley et al., 2022). Therefore, the collaboration between the lead author, the universities' athlete support officer and an accredited sport psychologist was a natural partnership for this type of project.

The performance context in which this research sits is the high-performance academy program of the university. This program offers support to talented athletes (competing at either national or international level) who are also studying at the university, with a specific focus on dual-career support. Given the context specified in the introduction, it was deemed important that these athletes had access to education on stress management and easy tools to achieve this. This is akin to best practice in performance domains where athlete welfare and performance excellence should co-exist (Kavanagh et al., 2021). Based on conversations between the athlete support officer and lead researcher, the intervention was devised to meet the athletes' needs, but also provide a platform to assess the effectiveness of the planned intervention. The end goal was to potentially roll out the program on a yearly basis for all athletes who were on the high-performance academy program.

Methodology

Study design

A mixed methods approach was used which allowed for a within subject pre- and post-test design with a follow-up qualitative focus group to determine the effectiveness and perceptions of the intervention.

Athletic population

Eight dual career athletes (age = 20.75 ± 1.38, 3 female) competing at either national (4) or international (4) level (years of experience = 8.93 ± 3.32) agreed to take part, they were part of the institutions high-performance athlete program as well as being current students. They were involved in a range of sports including wheelchair racing, athletics, basketball, golf and football. All athletes had no underlying health conditions that would affect the heart or lungs in daily function. One athlete reported they had exercise induced asthma, which was not affected by SPB. Ethical approval was gained from the lead authors institution and all athletes consented to the intervention.

Intervention outline

The intervention consisted of session 1: vmHRV and stress testing, session 2: SPB education workshop, four weeks of breathing training, session 3: vmHRV and stress testing (post), session 4: focus group (see supplementary material 1). The intervention ran across four weeks, a timeframe that has been used in similar app-based interventions (Rist & Pearce, 2017). The athletes were instructed to practice breathing for 10 minutes a day, this was chosen given there was no dose response found for different durations of SPB regarding vmHRV during and immediately after SPB (You et al., 2021).

Data analysis

Quantitative data from the measures taken were entered into Microsoft® Excel® and descriptive statistics were calculated for each (see supplementary material 2). These were then visually inspected to determine differences between pre- and post-intervention measures and graphical accounts of the data were created to display the changes over time. This method has been used in similar intervention research examining small sample sizes (Didymus

& Fletcher, 2017). The qualitative data from the focus groups were transcribed verbatim from the audio recording and analyzed using inductive thematic analysis procedures in line with Braun and Clarke (2019). HH transcribed the focus groups and HH, EM and EK read the transcript, devised themes, and agreed on final themes (see supplementary material 3). The thematic analysis was conducted in consultation with a number of the author team though a process of reflexive thematic analysis. As a research team we acted as critical friends' and the themes were discussed across a number of iterations. The thematic structure was presented at an international conference for feedback from critical scholars in the field and to refine the representation of the qualitative data. As a research team we believe the final themes presented in the paper represent the participants' collective experiences of the intervention. The process of choosing the data extracts was discussed by the research team and were chosen to best showcase the themes and bring to life participants' reflections of the applied intervention. This is in line with reflexive thematic analysis where the presentation of extracts is about the best representation of findings rather than presenting truth. The final decision of included quotes was the responsibility of the first author, these reflected participant experience of the intervention and best reflected the essence of the theme being presented.

Practical intervention

Session one

Prior to session one athletes were asked to not consume alcohol within 24 hours prior to and refrain from eating food or consuming caffeine for two hours prior to testing, to avoid any confounding effects on vmHRV measurement (Laborde et al., 2017). Upon arrival to the first session athletes were provided with an overview of the experiment and informed consent was gained (athletes were given the right to withdraw at any time). Athletes were taken to a testing room to undergo vmHRV screening and cognitive testing. Two disposable ECG electrodes were attached (placed in the right infraclavicular fossa and the second electrode aligned with the left 12th rib), followed by the eMotion Faros 180° device (Mega Electronics, Finland). Sampling rate was set to 500 hz as this is deemed to be a conservative sampling rate (Laborde et al., 2017). Athletes were then seated, arms in lap, palms upwards and eyes closed (Laborde et al., 2017) and a resting vmHRV reading was taken for three minutes. Stress intensity was then measured via a visual analogue scale (VAS), on which athletes placed a cross on a 100 mm line on "how stressed they felt as the present moment" which was anchored from "not at all stressed" to "extremely stressed" (Lesage et al., 2012). Following this, instructions regarding the Stroop test (Millisecond Test Library, Inquisit). This type of cognitive task is often used to induce stress

(Turner et al., 2012), as such, in the current study it was used as a stressor to observe differences in vmHRV pre and post intervention. The test consists of athletes responding to the color of a written word, for example the athlete will be presented with the word "green" but the color of the text is red—they must then react to this word correctly as red. This test is a short version of the Stroop test lasting three minutes and a priming script was read out to increase the importance of the task (e.g. athletes tend to be faster and more accurate, therefore you need to be as fast and accurate as possible). Following the task athletes rated their subjective stress and had a period of recovery for three minutes in which vmHRV was measured and a final subjective stress measure taken.

Whilst the other athletes waited for their testing slot, they completed the preliminary screening. This included screening for psychological distress via the Patient Health Questionnaire Anxiety and Depression Scale (PHQ-ADS), which is a composite measure from both the Generalized Anxiety Disorder Assessment (GAD-7) and Athlete Health Questionnaire (PHQ-9). The PHQ-9 is a valid measure of depressive symptoms and has been found to have internal consistency of α=.88 (Kroenke et al., 2001), with the current study reporting pre α=.79 and post α=.84. GAD-7 is a reliable measure of anxiety (α=.92) (Spitzer et al., 2006), with the current study reporting pre α=.90 and post α=.86. The PHQ-ADS is one of the shortest available and the brief nature supported its use in this study. Scores can range from 0-48, whereby the higher the score, the higher the distress (Chilcot et al., 2018), scores of 0-9 reflect minimal distress, 10-19 mild distress, 20-29 moderate and scores above 30 reflect severe distress (Kroenke, 2016).

Wellbeing was measured via the outcome rating scale which is a four-item measure of general wellbeing where athletes rate their wellbeing over the course of a week. It was developed as a simple and brief measure of wellbeing (Miller et al., 2003), which supported its use in the current study. It has four visual analogue scale wellbeing questions rated from low (0) to high (10) relating to individual (personal wellbeing), interpersonal (family, close relationships), social (work, school, friendships), and overall (general sense of wellbeing) (Miller et al., 2003). A total score is then created by adding the four subscales together, the scale has a high level of internal consistency (α=.93) (Miller et al., 2003), which was also reported in the current study (pre α=.80, post α=.90).

Athletes also answered questions regarding their knowledge of sport psychology and SPB. For example, "What is your knowledge of sport psychology" and "Are you familiar with SPB?". These questions were asked to check levels of knowledge pre and post intervention and to gain an understanding of previous experience with SPB interventions. No athletes had prior experience of breathing training before the intervention took place.

Session two

All athletes completed the preliminary screening and cognitive testing then took part in session two as a group, an in person SPB workshop which lasted approximately two hours. In this workshop athletes were provided with education around stressors they face as a dual career athlete and the benefits of SPB. For example, athletes were asked to write down stressors they were facing at the current moment in time, these were then discussed as a group and linked back to common demands dual-career athletes face. Following this, athletes were asked to write anything they did to reduce their stress, which led to the introduction of breathing techniques. Prior to learning about SPB athletes were asked to breathe normally for a period of one minute and count how many breaths they took during this time; this was to help demonstrate the differences in breathing rate. The group then followed breathing pacer (on the presentation screen) and monitored their heart rate to observe what patterns emerge during inhalation and exhalation. Athletes noticed how their heart rate increases during inhalation and decreases during exhalation, this phenomenon was explained to athletes as the beat to beat variation in response to breathing (respiratory sinus arrythmia) and how this links to more efficient gas exchange and increases vmHRV. Following this they were given training on breathing technique and the breathing application (freely available at the time of intervention - BreathPacer, IOS). The instructions were as follows: download the app and set inhalation to 4.5 seconds and exhalation to 5.5 seconds, as a longer exhalation in comparison to inhalation is recommended to increase vmHRV (Laborde, Iskra, et al., 2021; Van Diest et al., 2014). Once set up the breathing pacer displays a flower slowly adding petals to indicate inhalation (4.5s) and exhalation (5.5s) phases. Athletes were then told to follow the breathing pacer app whilst being aware of their body position. They were instructed to place their right hand on their chest and their left hand on their stomach, breathe in through the nose and their stomach should inflate (not the chest), and breathe out slowly through pursed lips. Athletes were told that they may feel dizzy during this process and to stop if they experienced these symptoms (see Laborde, Allen, et al., 2021 for another example of how breathing is taught). During the practice at rest this time the leaders of the workshop visually observed the athlete's technique and gave feedback. An example observation included athletes not fully expanding the belly (i.e. not utilizing the diaphragm enough), therefore they were prompted to focus on expanding the belly during inhalation. Athletes practiced breathing both at rest and during situations of demand (stress-based activities) to develop their understanding of the application of SPB. An example of using breathing during a stress-based activity was during a child's reaction time "electric shock" game, whereby the slowest reaction time receives a shock. Athletes were instructed to use the breathing technique during the phase where they would have to react, much like reacting to a start gun of a race, to keep themselves calm during the reaction time competition. Following the workshop athletes were instructed to practice SPB using the smartphone app breathing pacer for ten minutes every day, the specific inhalation, exhalation and duration of the breathing was set within the app prior to the athletes finishing the workshop. This was completed for a period of four weeks (the start of which was counted as the day of the workshop). No specific time of day was given for SPB practice to the athletes to allow for freedom and choice of when they used SPB. Over the four weeks athletes kept a paper breathing diary to monitor how often they adhered to the daily breathing exercises. Athletes marked how comfortable they found the breathing sessions each day on a scale of 1 (not comfortable) to 10 (very comfortable). This measure was inspired by Allen and Friedman (2012) as they stated the importance of understanding perceptions of breathing comfort due to participants experiencing negative affect in initial breathing sessions.

Session three

After the four-week period athletes returned for session three which consisted of a repeat of session one.

Session four

Lastly in session four, athletes took part in a focus group, in which they were asked to reflect on the intervention. This qualitative method allowed insight into athlete perceptions of how easy it was to complete SPB daily, when they adopted SPB, and their perception of the impact of SPB across multiple life domains. The focus group data was thematically analyzed to identify patterns and themes surrounding the SPB intervention.

Outcomes of intervention

Five of the eight athletes returned their breathing diaries and from the 28-day intervention an average of 1.6 days were missed. There was one set of missing vmHRV and Stroop data as one student had to go home before the final testing, they completed their follow up questionnaires via email. Five out of the eight athletes were able to attend the in person focus group, two answered the focus group questions via email, one did not respond.

Quantitative Results

Descriptive statistics can be seen in supplementary material 2 and graphical representation of quantitative outcomes can be seen in supplementary material 4. Across the quantitative results outcomes were mixed across the different athletes. From pre to post intervention the majority experienced an increase of total wellbeing (pre = 25.88 ± 8.52, post = 27.52 ± 8.20), and a decrease in psychological distress (pre = 9.50 ± 8.03, post = 7.12 ± 6.66), suggesting that breathing over this period may have helped to reduce stress and improve wellbeing. However not all experienced this, for example athlete 7 had a decrease in wellbeing and an increase in psychological distress pre to post intervention. Regarding the experimental stressor in session one and three of the intervention, there was an observed decrease in reaction time from pre (1014.73, ± 187.78) to post (861.14 ± 139.97) intervention (with the exception of athlete 7). However, this may have been due to familiarity of the task post testing and Stroop accuracy differences were negligible, suggesting breathing did not specifically influence performance. Finally, all athletes experienced a decrease in baseline vmHRV (RMSSD) pre (86.46 ± 27.95) to post (61.28 ± 30.69) intervention, suggesting that breathing did not improve resting levels.

Qualitative results

Thematic analysis of focus group responses highlighted three main themes: 1. Psychoeducation and SPB training, 2. Situational use and application of training, and 3. Psychological response (see supplementary material 3).

Psychoeducation and SPB training. Athletes commented that they benefited from the educational workshop prior to the breathing intervention (see quote from athlete 4). This again reinforces the need for an element of education around SPB prior to giving athletes daily breathing tasks. After the intervention all the athletes stated they understood SPB and how to use it effectively. The efficacy of education surrounding SPB was reflected in the focus group where it was recognized that SPB takes time to learn and is complex in the early stages of adoption.

> I don't think I would have known how to actually do it because up until then I would have just thought oh just breathing but to actually know the technique and stuff… And after a while it just became normal and like I remember the first week I was doing it I had to really like, sometimes I was doing the breathing but it wasn't like deep and after a while I got used to it. And I wasn't even thinking like I need to do it like this. (Athlete 4)

Not all athletes found that they improved over time, some were able to breathe at the given pace straight away. For example, athlete 2 suggested it was not better or worse from beginning to end. This is also an important consideration when developing breathing programs that athletes may have different abilities. This may be due to a number of factors including sport type, lung capacity and/or age; therefore it is important to take these into account when delivering education around breathing.

Situational use and application of training. Most athletes incorporated SPB into their routine before sleeping, such as setting alarm reminders. This was also considered to be the most convenient time to do SPB every day. The application of SPB training was mentioned in relation to sport but also in other life events, such as university assessments as suggested by athlete 3. This is crucial given the population we studied were dual career athletes who often have multiple stressors to cope with, therefore this shows that SPB could be applied to many different aspects of athlete's lives. Athletes also reported using SPB to help whilst doing gym-based sessions which is interesting given other evidence for short-duration intense exercise is suggested to be facilitated by voluntary hyperventilation (Forbes et al., 2007).

> So when I'm doing like abs, so I need to stay in the same position like for example like core and it's like really long and in the last set I'm just thinking of my breathing and it helped me to maintain the good shape. (Athlete 1)

This demonstrates that athletes used SPB in different ways and at different times. This seemed to be dependent on ease of practicing breathing within their daily routine i.e. before sleep, or event dependent when there was either significant psychological demand (i.e. university exams) or significant physical demand (i.e. during gym sessions, also see Laborde, Zammit, et al., 2022). Giving athletes freedom to choose when they practiced SPB therefore shed light on how it can be used in the future and recommendations practitioners could give for the use of SPB.

Psychological Response. There were a range of psychological responses reported which were linked to SPB. Three athletes commented on the using of SPB when experiencing stress. For example, athlete 2 was able to distract from life stress by focusing on the breathing technique. This is an important application as the athlete was able to recognize the stressor and use breathing to bring about feelings of calm, therefore this suggests athletes may use SPB to mitigate feelings of stress.

> Recently I've been trying to sort flights going home and when I was doing this at night basically I was more calm when I was thinking when I was breathing cause I didn't have much going on when I was focusing on this. (Athlete 2)

Athletes commented on how they used SPB during competition and the benefits this had on psychological state.

> For me I had the chance to use it on the golf course once because it went horribly wrong um and I just thought I was going to lose my temper and I just thought to focus on my breathing and hopefully it will get better. It didn't go any better but it didn't go any worse, so I thought I kept on the level on how bad it was but it didn't go any better. So I couldn't decide if it was better for me or not. The outcome was what it was. (Athlete 2)

Athlete 2 specifically states here they used SPB to help regulate their emotional state when performance was not going to plan, this therefore may be representative of more effective emotional regulation as a result of SPB. SPB increases vmHRV (Laborde, Allen, et al., 2022) and higher vmHRV is associated with more effective emotion regulation (Thayer et al., 2009). It is therefore suggested that the use of SPB during competition may provide a "psychophysiological boost" when needing to access emotion regulation resources mid-competition. This has also been mentioned in a longitudinal case study where an athlete used breathing specifically to cope with malfunctions in equipment during competition (Gross et al., 2017). Athlete 2 also suggested they used SPB to fill momentum shifts/ breaks in play. This may help as a distraction technique to focus on something productive rather than intrusive thoughts.

While some athletes did not have the chance to use it or felt the need to use it in competition at the end of the intervention, it was apparent that they saw the benefit of using SPB. For example, athlete 5 suggested they would use it prior to competition as they tend to get nervous. Using SPB prior to competition may be a useful exercise given the evidence around anxiety and decreasing vmHRV in the build up to important competitions (for a recent overview see Mosley & Laborde, 2022).

It is well known the SPB has relaxation effects and can positively influence sleep (Laborde et al., 2019; Bertisch et al., 2012). It was apparent from the focus group that the ability to get to sleep, and sleep quality was enhanced to the SPB intervention.

> Ok because my sleep is definitely getting better, so I can sleep and sometimes I can have ten and hours of sleep and when I wake up I feel so tired. Using the slow paced breathing my sleeping is definitely better for my recovery. So I can sleep for maybe like 6 hours and doing slow paced breathing I noticed that I was relaxed so the sleep was so much better and benefitted me. (Athlete 1)

Improved subjective sleep quality has also been found in a similar intervention using smartphone enabled SPB prior to sleep (Laborde et al., 2019). SPB increases vmHRV (Laborde, Allen, et al., 2022; Sevoz-Couche & Laborde, 2022) and given higher vmHRV is directly aligned with the restorative function of the parasympathetic nervous system (Laborde et al., 2017; Malik, 1996), it is unsurprising that athletes reported ease of sleeping and more effective recovery.

Using smartphones to deliver SPB interventions

The aim of this paper was to investigate the effectiveness and perceptions of a psychoeducation and smartphone enabled SPB intervention for dual career athletes. Athletes clearly saw value in the intervention as reported in the focus group and observations of the data showed that for the majority of athletes wellbeing was improved and psychological distress reduced. Given the ease and accessibility of delivering SPB interventions via smartphones, practitioners should consider using this as an applied tool in their practice.

We found that athletes picked up SPB at different rates and therefore this should be considered when delivering the initial education around SPB, for example allowing more acquisition time for those struggling with the technique or adjusting inhalation and exhalation ratios and slowly decreasing them to the recommended pace. We did not specifically state when athletes should use SPB to explore its use, it was shown from the feedback that athletes employed this method during competition, for lifestyle management and to affect the quality of sleep. Therefore, it may be important to think about the reason for using SPB as an intervention and the subsequent timing of its use (e.g., before competition to reduce nervousness or before sleep to improve sleep quality). This may be a particularly useful strategy if psychologists or coaches are working with athletes who are struggling with sleep—given this was the most reported use of the breathing app and the beneficial subjective effects surrounding sleep quality (e.g., Laborde et al., 2019). Practitioners could also think about the introduction of SPB with other complementary interventions such as mindfulness or imagery training.

Practitioners wanting to deliver SPB via smartphones should consider the following suggestions. Practitioners and athletes should use apps that allow for adjustments in the inhalation and exhalation ratio. Many apps offer this function, but it is important that practitioners know the rate in which breathing should be conducted for maximum effects on vmHRV (6 cycles per minute with a longer exhalation phase in comparison to inhalation, Laborde, Iskra, et al., 2021; Van Diest et al., 2014). Practitioners should also consider educating athletes on the psychophysiological effects of breathing using some form of accessible HRV device to showcase the direct benefits of SPB on the body and mind. An example of this could be using the EliteHRV™ application and a Polar® heart rate monitor and getting the athlete to breathe spontaneously (normally) and then at 6 cycles per minute to directly observe the physiological differences; as well as the HRV4Biofeedback application that does not require additional devices, providing HRVBFB via the smartphone camera (https://www.hrv4biofeedback.com). These accessible applications also provide HRV data to allow practitioners to help evaluate the intervention, as shown in the current study qualitative evaluations of SPB interventions are also useful in this applied context. In addition, there should be an element of acquisition time to allow the athlete to effectively learn a slower breathing pace, to then use SPB without the app when needed. While the largest increases of vmHRV are when breathing at a specific pace set by a breathing pacer with a longer inhalation than exhalation, slowing breathing in comparison to baseline breathing rate still increases vmHRV (Laborde, Iskra, et al., 2021). Therefore, there may still be scope to for athletes to gain benefits from SPB during competition when access to a breathing pacer is not possible.

Limitations and future directions

Limitations were present in the current project that should be highlighted. Three of the athletes did not return their diaries and therefore the fidelity of the intervention could be questioned. We used paper diaries which may not have been as accessible as using an online platform, digital daily check ins (such as whats app messaging) would most likely reduce missed days and ensure the intervention was being completed. However, we did feel that written diaries would allow athletes to elaborate if they felt they wanted to. Within the current intervention vmHRV (RMSSD) was not measured throughout and only at pre and post intervention, given the changeability of vmHRV it would be beneficial to increase the frequency of vmHRV measurements to ensure more rigorous vmHRV findings. While using a focus group allowed for discussion of the breathing techniques as a group directly after the intervention, they may not have allowed for athletes to be completely open about their experiences for example discussing sensitive experiences.

Future research should look to replicate a similar intervention in athletic populations on a larger scale to determine the influence of smartphone application SPB over time. In the current study a period of four weeks was used, however some athletes were able to pick up SPB very quickly and others took more time. Alongside this, further research should assess the daily duration of SPB and how this may influence intervention outcomes (i.e., dose-response relationship) (You et al., 2021). Research could consider using biofeedback systems, displaying either heart rate, vmHRV, or respiratory information (Laborde et al., 2021), such as with respiration belts to physical test the ability to breathe at the correct rate over time, which would give more objective evidence. Future research may use dyadic interviews (e.g., between practitioners and athletes or between coaches and athletes) to better explore the shared perception of SPB acquisition and use. This will help to better inform interventions using SPB, and hopefully lead to more research which can develop clear applied guidelines in the future. While this research has some limitations, it is an important first step to clarify how SPB could be delivered to athletes and builds a platform to encourage coaches, athletes, and researchers to further understand how to best implement SPB within the sport context.

Disclosure statement and data availability

The authors report there are no competing interests to declare. Data is available on request.

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