BMC Psychology

RESEARCH Open Access

Enhancing psychological skills and well-being in sport through an app-based blended intervention: a randomized controlled pilot study

Sara Bordo[1*], Gabriele Costanzo[2] and Daniela Villani[3]

Abstract

Background Mental preparation is a fundamental aspect of athletic performance. We present here an experiment aimed at evaluating the effectiveness of a blended intervention to promote mindfulness and self-confidence and a reduction of anxiety among professional athletes.

Methods The intervention, delivered through an application for smartphones, included eight weekly modules with variable and progressive training and relaxation exercises. Meetings with the athletes took place every 2 weeks. The study involved 41 tennis players who were randomly assigned to either the intervention or the control group. Data were analyzed via repeated measures ANOVA.

Results The results showed a significant change in self-confidence, arousal control, anxiety, awareness and refocusing in the experimental group and no significant change in the control group.

Conclusion The blended intervention showed good results in only 8 weeks, thus again emphasizing the effectiveness of breathing and relaxation techniques opening the door for future studies and interventions that can use new technologies to promote athletes' well-being and performance.

Trial registration Current Controlled Trials NCT06212986, 01/18/2024 - Retrospectively registered.

Keywords Mobile app; blended intervention; psychological well-being, Sport, Mental training, Tennis players

*Correspondence:
Sara Bordo
bordo.sara@gmail.com
[1]Sport Psychologist, Department of Psychology, Università Cattolica del Sacro Cuore of Milan, Milan, Italy
[2]Cognitive-Behavioral Psychotherapist (IPSICO), Clinical and Sport Psychologist, Florence, Italy
[3]Department of Psychology, Università Cattolica del Sacro Cuore of Milan, Milan, Italy

Background

Mental training in sport refers to a set of techniques that, among others, can help the athlete to enhance their ability to control stress and improve concentration and competitive performance [1]. According to most coaches, mental preparation represents a fundamental aspect of success in athletic competitions and can make the difference even with an opponent of similar skills [1]. Furthermore, research in sport psychology has shown that mental training may play a critical role not only in athletes' performance but also in their psychological well-being. Two well-known forms of mental training are psychological skills training (PST) and mindfulness training (MT) [2].

PST refers to the systematic and consistent practice of mental or psychological skills that are aimed at enhancing performance and at increasing pleasure and satisfaction in sport [3]. The ultimate goal of PST is to enable athletes to manage their thoughts, emotions and behaviors [3] through the combination of several techniques such as relaxation, positive self-talk, or reframing of negative thoughts.

The second is MT, developed for sports psychology by Gardner and Moore [4], and it is based on the promotion of acceptance and the non-judgmental awareness of the present moment. MT is inspired by the mindfulness-acceptance-commitment (MAC) approach [5] and argues that optimal performance does not necessarily come from reducing or minimizing negative internal states. Rather, performance results are affected by the athletes' ability not to mentally judge the present, that is, the task they are performing, through their experiences. The MAC protocol [4] employs a series of experiential techniques and exercises aimed at increasing awareness and non-judgmental acceptance of cognitive, sensory and affective experiences.

Multimodal interventions (activation regulation, visualization, self-talk, and goal setting) were found to be effective in improving attention and emotional control compared to control groups [2, 6]. In fact, by examining the effectiveness of psychological skills training (PST) and mindfulness-based interventions (MBI) in enhancing athletic performance, Röthlin and colleagues [2] found that a combination of both interventions might provide a more comprehensive approach to optimizing athletic performance. Both interventions contributed positively to athletic performance, but through different psychological mechanisms: PST primarily improved goal-setting and self-talk, whereas MBI enhanced mindfulness and emotional regulation [2, 6].

Both PST and MT share the goals of enhancing athletes' psychological skills by using similar common strategies. For example, focusing attention on breathing is a widely used technique in all approaches, even those with different goals. In PST it is used to manage anxiety and reduce physiological activation, while in MT it is conceived as a strategy to stay focused on the present moment. Research has shown that the ability to consciously stay in touch with one's breath is negatively correlated with depression, rumination, and repetitive negative thoughts [7], acting on an overall improvement in psychological and physical well-being [8]. In particular, slow breathing techniques improve interactions between autonomic, cerebral, and psychological flexibility, linking parasympathetic and central nervous system activities related to both emotional control and well-being [9], and diaphragmatic breathing facilitates increased air volume reserve and ventilation, and decreases respiratory rate and dyspnea [10].

With a particular reference to the tennis context, Mamassis and Doganis [11] developed a multimodal mental training program and tested its significant effects in reducing pre-competitive anxiety and increasing self-confidence among junior tennis players. Additionally, authors found a marked improvement in tennis performance, indicating that mental training can be a valuable tool in enhancing both psychological and performance aspects of young athletes [11]. More recently, Dohme and colleagues [12] explored development, implementation, and evaluation of a mental skills training program specifically designed and tailored for elite youth tennis players, according to their psychological challenges and needs. This study also demonstrated the potentialities of mental training interventions in enhancing mental skills, performance and psychological well-being [12].

Digital technologies for athletes' well-being

The technological revolution of the twenty-first century, as reported by Howells and colleagues [13], has affected all aspects of daily life, including thoughts, behavior, and social interactions in a whole new and unexpected way. Smartphones have played a fundamental role in this revolution [13] together with the development of remote training interventions aimed at promoting individuals' well-being through mobile apps [14]. Mobile phone apps are accessible at any time and in any place and allow for great user flexibility in frequency or amount of use [15]. Given these advantages, research has shown that young adults prefer digital interventions to increase their well-being and mental health over face-to-face therapies [16]. Furthermore, given the large annual expenditure on mental health services, many resources are being invested in proactive programs aimed at promoting mental well-being in non-clinical populations [17]: this is an approach believed to be effective and low cost [18].

The proliferating development of these digital applications is related to the field of applied positive psychology [19] and it is called Positive Technology (PT) [20, 21]. PT

specifically aims at investigating how ICT-based applications and services can be used to foster positive growth of individuals, groups and institutions by focusing on the design, development, and validation of novel digital experiences that aspire to promoting positive change through pleasure, flow, meaning, competence, and positive relationships [22, 23].

Up to now several apps using psychological skills training or mindfulness interventions have been developed and tested. One of the best known and most downloaded apps is Headspace [24], which uses mindfulness and meditation exercises to help the user learn about and practice meditation [25]. Another widely downloaded app is Calm, which is based on the principles of mindfulness and meditation and allows users to develop mindfulness skills, practice meditation, and track their mood and feelings over time [25].

Despite all the evidence regarding the effectiveness of mobile interventions in promoting individual well-being in several contexts, these interventions are very rare in sport [26], and athletes are looking for digital tools aimed at improving their performance. Several studies integrated a blended PST approach with mindfulness exercises through audio-guided contents focused on breathing, relaxation techniques and body scanning [27], and results showed a significant increase in concentration and self-efficacy.

Furthermore, recently, Kittler et al. [28] implemented a 6-week blended program combining the use of a mindfulness based app, aimed at enhancing awareness to improve attention regulation, with six face to face workshops (one per week) focused on meditation techniques, body scanning, and emotion awareness. Unexpectedly, results showed that the application was underused. In fact, the improvements found in attention skills did not appear to be associated with the use of the app (only 30.51 min) but with participation in the workshops (average of about 200 min total). Thus, the authors highlighted the importance of providing assistance to users to promote their engagement and to enhance the effects of the app-based intervention.

Although the rapid expansion of mobile applications offers the opportunity to develop self-help or guided interventions that encourage healthy behaviors and well-being in several contexts [29], the proliferation of apps on the market have rarely been supported by empirical evidence [30] and a recent investigation [31] found that, within the sports context, mobile apps aimed at training specific skills had a low rate of user involvement. A way to increase user engagement with mental health apps can be through *blended interventions* [32], combining digital and online contents and activities with traditional analogous methods, like face-to-face meetings. Besides user engagement, *blended interventions* can improve motivation and adherence and allow to practice mental techniques according to individual time [33]. Blended interventions are frequently used in care settings and several studies showed their potentialities also in sport [31, 34].

In the specific context of tennis, no specific apps aimed at promoting psychological well-being have been developed and tested with controlled studies to date. Recently, Bilić and colleagues [35] assessed the accuracy and reliability of a mobile application designed to track tennis performance through an application for the automatic analysis of movement and specific parameters in tennis. The results showed that the application was an helpful tool in the training process of tennis players at all levels of the game; however, it was not designed for enhancing athletes' psychophysical well-being.

Present study

The present pilot study was aimed at evaluating the effectiveness of a blended research combining the intervention of a professional and the use of the Perform-UP Tennis app to promote athletes' mindfulness, self-confidence and to reduce anxiety. Another aim was to evaluate the user experience and the quality of the mobile app as assessed by the athletes. To achieve these goals, this study employed a mixed-methods approach, integrating quantitative and qualitative measures to provide a comprehensive understanding of the intervention's effects.

Methods

The app Perform-UP Tennis, available for Android and IOS, has been developed by the first author, a sports psychologist, to help athletes maximize their sports performance, based on the latest scientific evidence. Perform-UP Tennis is a sport specific mental training app that integrates breathing, relaxation and nature-based guided imagery exercises and aims to promote emotional well-being and the enhancement of mental skills. The app techniques are integrated into a single gradual path that involves increasingly complex breathing and relaxation exercises with increasing duration. The athletes' mental pathway is customized based on age, gender, level and dominant arm.

The app includes both (1) exercises to promote emotional and psychological sport skills in order to manage anxiety and arousal, and to promote self-confidence and the ability to be focused and aware of cognitive and affective states during tennis practice and (2) exercises to improve the mental imagery. This study was focused mainly on evaluating only a first set of exercises (see Table 1).

The intervention consisted of eight weekly modules, representative of all exercise categories within the application and specifically those related to breathing and

Table 1 Type and description of exercises included in Perform-UP tennis app and promoted skills

Exercises	Expected outcomes	Week of intervention and number of proposed exercises
Diaphragmatic Breathing [8]	The correct execution of the exercise will allow the athlete to: · Decrease heart rate and respiratory rate · Re-educate the movements of the diaphragm · Increase relaxation and decrease anxiety	Week 1 (4 exercises) Week 2 (3 exercises) Week 3 (2 exercises) Week 4 (3 exercises) Week 5 (2 exercises)
Visualization of naturalistic environments [39]	Proper execution of the exercise allows the athlete to: · Develop a sensation of well-being spread throughout the body · Promote relaxation and decrease anxiety · Lighten the flow of thoughts that dominate the mind	Week 3 (2 exercises) Week 4 (1 exercises) Week 5 (2 exercises)
Square breathing [40]	Proper execution of the exercise allows the athlete to: · Promote concentration · Regulate blood pressure and heart rate · Increase awareness of one's breathing	Week 6 (2 exercises)
Relaxation technique focusing on positive energy [16]	Proper execution of the exercise allows the athlete to: · Improve the emotional state · Increase self-confidence and motivation · Experience a feeling of mental and physical well-being	Week 6 (2 exercises)
Deep breathing (exhale twice as long as inhale) [7]	The correct execution of the exercise allows the athlete to: · Improve concentration · Activate the parasympathetic system · Decrease mental stress and negative emotions	Week 7 (3 exercises) Week 8 (2 exercises)
Mindfulness inspired techniques focusing on bodily sensations [41]	Proper execution of the exercise allows the athlete to: · Focus on the present · Improve awareness of internal states · Promote concentration	Week 8 (2 exercises)

relaxation sections, over a period of 8 weeks with progressive exercises during season. The duration of the intervention, spanning several weeks, was consistent with that of other interventions, such as those of Kittler and colleagues [28], who implemented a 6-week blended program based on a mindfulness app, of Walsh, Saab and Farb [36], who investigated the effects of a mindfulness meditation app on subjective well-being through an active randomized controlled trial over a period of 3 weeks, and of Busch and colleagues [37], who explored the effects of using a fitness app over a period of 6 weeks on psychological well-being and body awareness.

Participants were randomly assigned to either the experimental blended group (Perform-UP group), that used the application on their own and also met up with a professional sports psychologist every 2 weeks for debriefing, and a control group that did not use it. A free online software (Research Randomizer 4.0) was used to generate the randomization list. Participants were asked to answer a series of questionnaires at two separate stages: at the baseline, i.e., before starting the use of the Perform-UP Tennis app (T0), and eight weeks later, i.e., at the end of the intervention (T1). The times of assessment were the same for the two groups. The app was available for free for tennis players who were interested in taking part in the study (the control group received the app free of charge after completing the second assessment).

The G-power software was used to estimate the number of participants required. Assuming a medium effect (Cohen's d of 0.5), in line with the positive psychology intervention's impact on well-being [38], a sample of 44 (22 in each group) was needed to detect a difference between two means with 95% power in a repeated measure design - within/between interaction (number of groups: 2; number of measurements: 2; correlation between repeated measurements: 0.05). The study was approved by the Ethics Committee of the Psychology Department of the Università Cattolica del Sacro Cuore di Milano, Italy.

Participants

Since Perform-UP is an application developed specifically for tennis, an e-mail introducing the research project, with the methodology and information needed to participate, was sent to tennis clubs throughout Italy the researchers knew personally. They were informed that participation was voluntary and that they were free to drop out of the study at any time and that all data would be considered confidential. The inclusion criteria were: being tennis players with a minimum age of 14, being fluent in Italian, and having a smartphone with an Internet connection. Athletes who decided to take part in the research sent back a completed informed consent form and received a one-year free subscription to the Perform-UP Tennis application. Also, the parents of the junior athletes (aged 14–18) signed a consent form for their child to participate in the study.

Forty-five competitive tennis players were enrolled in the study, and they were randomly assigned to Perform-Up group ($n = 24$) and control group ($n = 21$). See Fig. 1 presenting the flow diagram of participant progression throughout the study. To assess the effectiveness of the program, we included in the analysis only the athletes

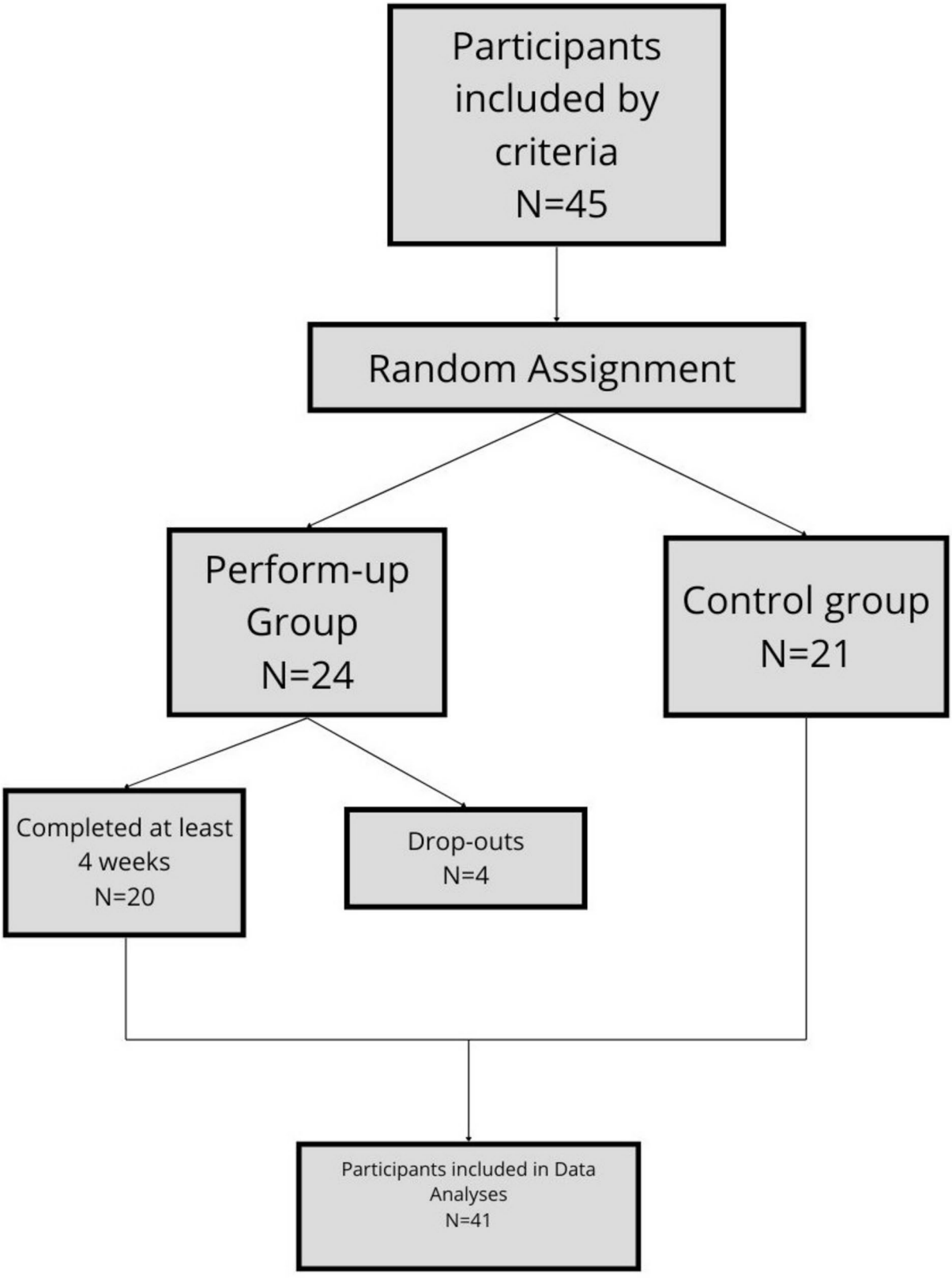

Fig. 1 Flow diagram of participants progression

who had completed at least half of the program, meaning 4 out of 8 weeks. Based on this criterion, we excluded from the analysis four participants in the Perform-Up group who had not completed the activities for at least 4 weeks. Finally 41 tennis players (20 in Perform-Up group and 21 in the control group) took part in the research project and were considered for the analysis.

Measures

This study adopted a mixed-methods approach, combining quantitative and qualitative measures to assess the effectiveness of the intervention and the mobile app user experience.

A series of self-assessment questionnaires were used to determine changes in psychological abilities and to assess participants' overall experience with the Perform-UP intervention. Data were collected at the baseline and at the end of the intervention (after 8 weeks), except for the rated quality of the application, which was evaluated only at the end of the intervention. Internal consistency for each subscale was calculated (Cronbach's α).

The Psychological Inventory of Sport Performance (IPPS-48) [42] was used to evaluate the athletes' sport performance in terms of the relevant mental skills. This scale consists of 48 items reflecting eight distinct components of mental skills (concentration, arousal control, preparation of the match, goal setting, visualization, cognitive anxiety, self-confidence and self-talk), each assessed with six items. Each item is a statement, responded on a 5-point Likert scale. For this research, we considered only three subscales that were consistent with the activities proposed within the application (breathing and relaxation techniques). For this reason, the scales considered were: (1) cognitive anxiety (α = 0.88), evaluating the athlete's level of concern during the match, fear of making mistakes, and fear of failing (e.g., "Before the competition I always have a sense of panic"), (2) self-confidence (α = 0.89), evaluating the confidence that the athlete has in being able to compete at their best, to give their best and to believe in themselves. (e.g., "I consider myself a determined person when I compete"), (3) emotional arousal control (α = 0.82), evaluating the athletes' ability to relax when they feels anxious and under tension and to activate themselves when they need to reach the right energy level (e.g., "When I am feeling too tense to do what I have to do, I know I can relax").

The Mindfulness Inventory for Sport (MIS) [43] was used to evaluate the awareness processes within the athlete's sports performance. This scale consists of 15 items reflecting three distinct components of mindfulness. Each scale includes five items, to which the athletes respond on a 5-point Likert scale. It contains both positively and negatively worded items (the non-judgmental subscale was reverse scored). Specifically, the questionnaire presented assessed: (1) Awareness, being aware of stimuli and their associated internal reactions (e.g., "I am aware of the intensity of nervousness in my body," α = 0.77), (2) non-judgmental, adopting a non-judgmental attitude towards these stimuli and reactions (e.g., "When I become aware that I am not fully focusing on my game, I blame myself for being distracted," α = 0.86), (3) refocusing, quickly refocus attention on target signals (e.g., "When I become aware that some of my muscles are aching, I quickly refocus on what to do," α = 0.74).

The Mobile Application Rating Scale (MARS) [44] was used to assess the quality of the mobile health application. Specifically, this self-report scale measures four dimensions through 19 items: (A) engagement (5 items: fun, interest, individual adaptability, interactivity, target group) (α = 0,77), (B) functionality (4 items: performance, usability, navigation, gestural design) (α = 0.84), (C) aesthetics (3 items: layout, graphics, visual appeal) (α = 0.78), and (D) information (7 items: accuracy of app description, goals, quality of information, quantity of information, quality of visual information, credibility, evidence base) (α = 0.84). All items are assessed on a 5-point scale (1-inadeguate, 2-poor, 3-acceptable, 4-good, and 5-excellent). In addition to these four dimensions, two other aspects were investigated: subjective evaluation of the user on the app (α = 0.83) and specific questions on the contents and exercises of the app (MARS specific) (α = 0.92). We have also included specific ad hoc questions to integrate the users' qualitative assessment of their experience. In addition, qualitative questions were inserted to investigate: satisfaction gained from their intervention, the importance of the presence of the professional and the benefits obtained.

Procedures

The intervention tested in this study was carried out over the course of 8 weeks. Each week, different breathing exercises (diaphragmatic, square and deep) and relaxation exercises (focus on positive energy, relax with diaphragmatic breathing and relax your body) were planned (see Table 1 for a description of exercises and expected outcomes). The mental training intervention consisted of weekly exercises (Fig. 2 and B), which were gradually released following the conclusion of the exercises scheduled for the week prior and the achievement of the designated medals signifying the completion of the week's exercises (Fig. 2 and C). Before each new exercise, a video presenting the technique to be practiced was shown (Fig. 2 and A). Each week contained 3 to 4 exercises lasting 3–7 min (Fig. 2, B and C). The duration of the exercises increased over the weeks. To maximize applicability and generalizability of the results, participants were free to use the app (timing, location, etc.), but were strongly

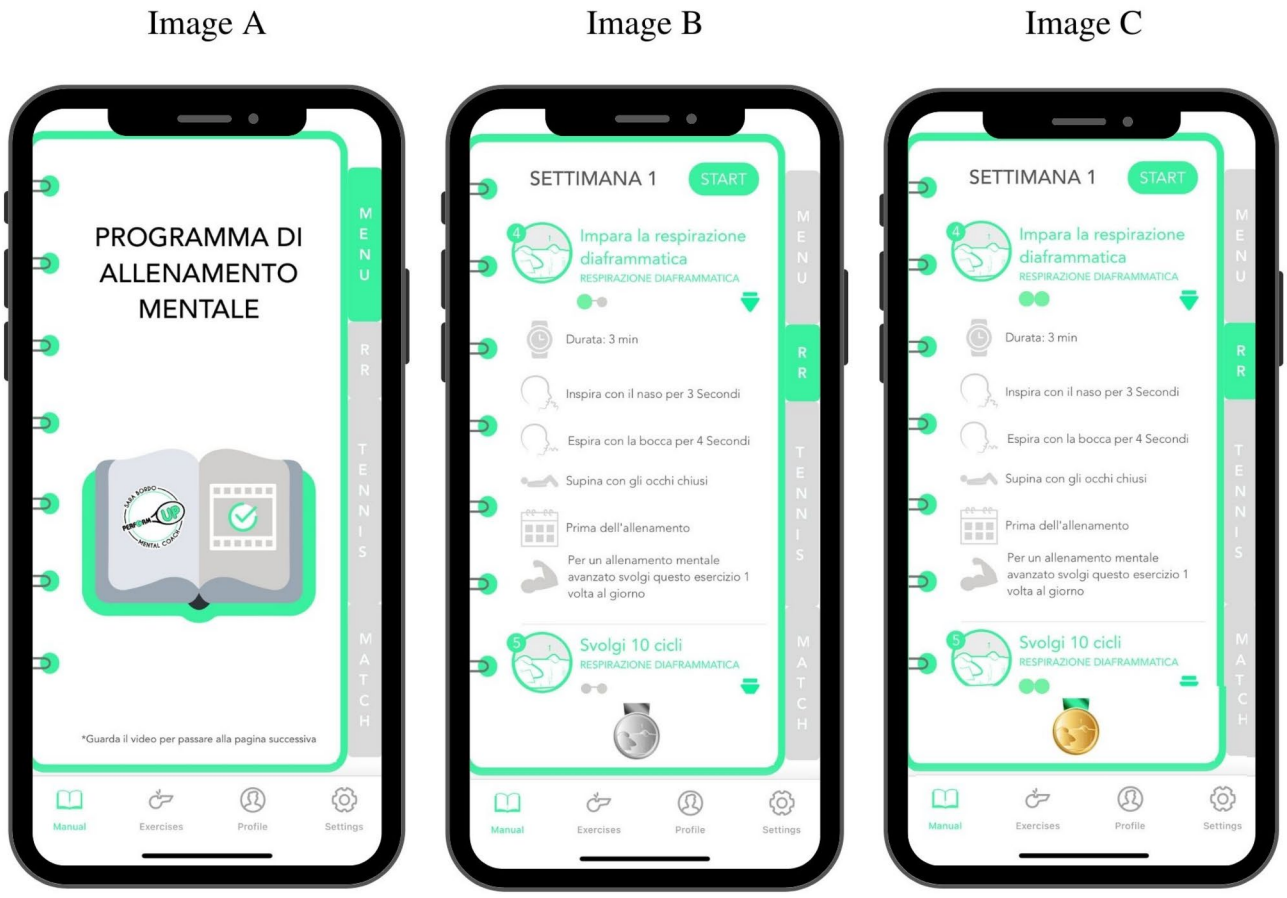

Fig. 2 Perform-UP intervention: Image **A** (homepage of the app), Image **B** (Week 1 not completed- grey medal), Image **C** (Week 1 completed- colorful medal)

encouraged to practice at least one exercise a day for 8 weeks.

To sustain active participation in the mobile intervention, tennis players in the Perform-UP group were invited to take part in 20-min online individual sessions with a sport psychologist every 2 weeks to share comments about the activities carried out, for a total of four online meetings. More specifically, during the meetings, the psychologist addressed any potential difficulties the athlete encountered while using the app. The psychologist also ensured that the athlete was completing the exercises and making progress with the mental training program, and discussed the athlete's perceptions of the usefulness of the proposed exercises. Both groups at the end of the training (T1 after eight weeks) completed the online questionnaire including the IPPS and the MIS. The MARS questionnaire was only proposed to the experimental group.

Data analysis

A SPSS software (IBM SPSS version 26.0) was used to analyze data. Continuous variables are reported as means and SD for normally distributed variables (age, IPPS and MIS subscales), whereas categorical variables (education level, employment status, previous meditation, breathing and mental training experience) are reported as frequencies and percentages. The normality of the distribution was tested with the Shapiro– Wilk normality test. Independent samples t-test at the baseline were performed to test the difference between groups (Perform-UP group and control group) for continuous variables (cognitive anxiety, arousal control, self-confidence, awareness, non-judgmental, refocusing) and a chi-square test was run for categorical data (gender, education level, employment status, relaxation and breathing experience, mental training experience, tennis ranking). No significant differences emerged between groups at baseline. In line with the goal of the study, a repeated measures ANOVA were used to test the effectiveness of the blended intervention on cognitive anxiety, emotional arousal, self-confidence and awareness of internal moods, non-judgmental attitude and refocusing attention, compared to the control group.

Table 2 Socio-demographic and sport descriptive data

Participants' characteristics	Perform-UP group (*n* = 20)	Control group (*n* = 21)
Age	*25.6 (14.34)*	*24.48*
Gender		*(11.71)*
Male (%)	*12 (60%)*	*11 (52.4%)*
Female (%)	*8 (40%)*	*10 (47.6%)*
Education level	*10 (50%)*	*7 (33.3%)*
Primary school	*7 (35%)*	*9 (42.9%)*
Senior high school	*2 (10%)*	*3 (14.3%)*
Bachelor's Degree	*1 (5%)*	*2 (9.5%)*
Master 's Degree		
Employment status		
Employed	*7 (35%)*	*8 (38.1%)*
Unemployed	*0*	*0*
Student	*13 (65%)*	*13 (61.9%)*
Previous relaxation and breathing experiences	*5 (25%)*	*8 (38.1%)*
Previous mental training experience	*7 (35%)*	*6 (28.6%)*
Tennis ranking		
N.C.	*2 (10%)*	*5 (23.8%)*
4^ Cat.	*6 (30%)*	*3 (14.3%)*
3^ Cat.	*9 (45%)*	*9 (42.9%)*
2^ Cat.	*3 (15%)*	*4 (19%)*

Table 3 Effectiveness of the intervention

	T0 M (SD)	T1 M (SD)	Interaction effect Time x Group		
			f	p	η2
Cognitive anxiety[a]					
Perform-UP group	4.06 (0.87)	3.47 (0.91)			
Control group	3.55 (1.01)	3.44 (0.98)	4.651	0.037*	0.107
Self-Confidence[a]					
Perform-UP group	3.41 (0.89)	3.87 (1.04)			
Control group	3.8 (1.12)	3.85 (1.22)	7.374	0.010*	0.159
Arousal[a]					
Perform-UP group	2.87 (0.70)	3.62 (0.69)			
Control group	3.07 (0.83)	3.40 (1.03)	4.404	0.042*	0.101
Awareness[b]					
Perform-UP group	3.85 (0.90)	4.37 (0.70)			
Control group	4.18 (1.01)	4.09 (1.05)	4.644	0.037*	0.106
Non-judgmental[b]					
Perform-UP group	2.99 (1.03)	3.04 (0.96)			
Control group	3.09 (1.25)	3.36 (0.96)	0.740	0.395	0.019
Refocusing[b]					
Perform-UP group	3.26 (0.89)	3.89 (0.92)			
Control group	3.68 (0.78)	3.7 (0.91)	7.238	0.010*	0.157

[a] Psychological Inventory of Sport Performance (IPPS) subscales score ranging from 1 to 6; [b] Mindfulness Inventory for Sport (MIS) subscales score ranging from 1 to 6

*Significant results

Results

Descriptive statistics

The sample group was made up of forty-one tennis players (23 males and 18 females) casually randomized to the blended Perform-UP and control groups. All socio-demographic descriptive data and sport characteristics are shown in Table 2.

Descriptive data of psychological dimensions are reported in Table 3, together with results from Repeated Measures ANOVA.

Effectiveness of the Perform-UP intervention

The Repeated Measures ANOVA showed significant interaction effects on all IPPS considered dimensions (see Table 3). Specifically, the Perform-UP group exhibited a significant decrease in cognitive anxiety and a significant increase in emotional arousal and self-confidence compared to the control group.

Regarding the three dimensions of the MIS, a significant interaction effect was found in awareness and refocusing, with the Perform-UP group achieving better outcomes. Results, however, did not show an effect related to having a non-judgmental attitude, which remained stable in both groups.

Quality of app and users' evaluation of the intervention

To evaluate the quality of the app, we referred to the involvement, functionality, aesthetics and quality of information dimensions from the MARS questionnaire. Descriptive data showed that the Perform-UP group evaluated very positively (more than 4.0) functionality ($M = 4.36$, $SD = 0.72$), quality of information ($M = 4.27$, $SD = 0.65$) and aesthetics ($M = 4.10$, $SD = 0.65$) of the app as well as positively evaluated (more than 3.5) its subjective quality ($M = 3.92$, $SD = 0.66$) and engagement ($M = 3.79$, $SD = 0.70$).

Through the MARS questionnaire, the participants' interest in the application and whether they would recommend it was also assessed. Participants rated the application as very interesting ($M = 4.3$). In their responses to the open question, they stated that the application is innovative, well designed and easy to use ("It is well designed and structurally catches one's attention"; "I really like how it is structured, but also the design and it is very easy to use"). Many users underlined the positive involvement (gaming) of the app structure ("The medals, as well as giving the impetus to improve, also make me think that this app is a game to complete"; "Because the graphics and exercises contained within stimulate you to use it a lot, follow it and do your best ") the app also offers the opportunity of having mental exercises at hand to be used as you wish ("Time-saving, as I can do the exercises without having to use other tools ";" Because it's like always having a coach in your pocket who advises and reminds you about what you need to do to improve your tennis skills"; " Because it makes me undertake techniques that I have never tried before"; "Teach new things").

Fifteen out of twenty participants said they would recommend the app to others. In particular, they would recommend it because it is useful ("It's a great app and it helps a lot"; "I think it's a good experience and it is certainly very useful and efficient"; "It can be useful to all kinds of people"), it allows to achieve sporting goals and one's own well-being ("It can be used to improve sports performance, but also to manage difficult situations in everyday life"; "Because by using this app, results can be obtained in both tennis and everyday life"; "Because it helps a lot to increase psychophysical well-being in general, not just to prepare for sport").

Furthermore, we integrated the exploration of participants' subjective experience with the Perform-UP Tennis App by analyzing their answers to further ad hoc questions. Several topics were explored including: satisfaction with the intervention (rating from 0 to 10 and open ended answers), perceived benefits (dichotomous yes/no answers and open ended answers), and evaluation of the presence of the professional (not useful, useful, the app was already exhaustive and complete).

Participants were highly satisfied with the intervention ($M = 8.5$). In particular, they reported that the intervention allowed them to: have a positive and educational experience ("It helped me focus day by day without losing perspective on my life"; "It enriched me personally"; "I think it was a magnificent experience, different from what was considered usual"), enhance performance ("Because for the first time, I found I was able to improve quite a few aspects of my game. The project also made me understand that non-professionals can improve their game as long as they put effort and passion into it") and improve their ability to manage emotions ("It helped me a lot to contain and control my emotions and thoughts and also to relax "; "Because I applied it during the matches and it was useful as I was able to overcome tension and have more confidence in myself"; "Useful and well guided and exercises to manage sensations and relax the body through breathing"; "I found it very useful and helpful in focusing not only in sport but also in everyday life. I became more positive and relaxed").

Tennis players reported benefits in terms of well-being (nineteen out of twenty responded positively). They affirmed that the techniques in the app allowed them to learn how to breathe properly ("I learned to give importance to breathing, which is often quite underestimated"; "They contributed… to proper breathing") to relax by increasing control of their own body ("I generally feel much more relaxed both on and off the court; I approach situations with a different mentality"; " The app helped me to relax and therefore enhanced my bodily feelings during training "), be more positive on and off the court and experience a real sense of well-being ("Gives a strange sense of peace, actually"; "Perfect when having to find alternative solutions to problems and reach a much better outcome";"The techniques in question have helped me maintain focus on my game, be positive and not to become discouraged").

Furthermore, seventeen out of twenty participants declared that they have used the techniques even outside the sporting context, in particular at work, at school (exams, before assessment tests, to increase concentration in studying), in personal life and to sleep better.

As far as the evaluation of the presence of the professional, sixteen participants found the presence of the professional useful to better understand the exercises proposed in the app, three found the presence of the professional to not be useful and one participant found the app already meticulous and complete. In particular, they claimed that the professional helped them understand the techniques better, thus maximizing results and discussing any difficulties they came across.

Discussion

This pilot study assessed an application of the positive technology approach. It was aimed at testing the effectiveness and feasibility of a blended intervention, based on the use of the Perform-UP Tennis app, on the enhancement of the athletes' awareness of their internal thoughts and feelings (mindfulness), self-confidence and on the reduction of both the cognitive and arousal dimensions of anxiety. Despite the small sample size, the results seemed to confirm the effectiveness of the proposed intervention on tennis players' self-confidence, cognitive anxiety and emotional arousal control. Furthermore, significant differences between groups were found in the athletes' levels of awareness of internal states and refocusing of attention, while no significant differences emerged between groups regarding the non-judgmental dimension. This result appeared consistent with the content of the app, which did not include these types of exercises. The positive changes that were found in this pilot study seemed to confirm the benefits of integrating breathing (diaphragmatic, deep and square) exercises and nature-based guided visualizations with meetings with the professional to promote psychological skills in sport settings.

On the one hand, breathing exercises represent a versatile technique which has been integrated within different approaches. Specifically, within the MT approach, breathing is used to guide athletes to focus attention on the physical sensations of their breathing and to increase the ability to be aware of distracting stimuli [4, 45, 46], while in PST, breathing is used to promote relaxation and to reduce the physiological and psychological dimensions of stress and anxiety.

On the other hand, several studies have shown the effectiveness of nature-based guided imagery to manage

anxiety, promote relaxation [39] and improve self-esteem [47]. Thus, imaginative relaxation exercises have helped athletes to improve not only their ability to manage their emotions but also their self-confidence. In particular, the gamification approach proposed by the Perform-UP Tennis App could have contributed to enhanced self-confidence. In health apps, gamification supports people in pursuing goals and improved performances [48], such as running faster or eating healthier, through the definition of goals and the strategy of rewards that frame behavioral change in terms of points gained, levels achieved and other similar markers [49]. The Perform-UP Tennis App proposed weekly exercises, turning colorful when completed in order to accompany the training path, and a colorful medal to signal the achievement of the goal.

Furthermore, not to be underestimated is the role played by the professional in supporting the motivation of the athletes and accompanying them during the eight weeks of intervention. Sport psychologist can be a crucial component for the success of the PST interventions [50] and recent studies have shown the importance of integrating professional assistance to sustain users' adherence to the at-distance intervention [28]. In this study, although the individual meetings with the professional were scheduled online every two weeks and had a short duration, progress may have been improved by the presence of a figure that reinforced the meaning and importance of the proposed activities. Moreover, as shown in a recent study that tested the effectiveness of the Calm application [51], the mindfulness awareness experience may not be easy to practice at a distance, and difficulties in managing negative thoughts, which emerge during meditation, can worsen the user's mental state [52]. The presence of the professional in this research facilitated athletes achieving better understanding of some of the difficulties they were coming across. Tennis players explicitly appreciated the guided dimension of the approach in the open-ended responses given at the end of the intervention and 16 out of 20 were fully in favor of the presence of the professional because this led to a better understanding of the techniques dealt with during the previous weeks and helped clear up any doubts that arose.

Finally, we assessed the users' experience in using the app and their satisfaction through ad hoc closed and open questions. The Perform-UP app group had higher scores in all domains: functionality, information, aesthetics, engagement, and total score. The presence of features and techniques such as semi-automated tracking (self-monitoring) inside the apps were associated with higher app quality scores in MARS in previous research, specifically for engagement, functionality, and aesthetics [53]. The high scores obtained by the Perform-UP group in those dimensions could be explained by the inclusion of a "feedback" module that allowed athletes to monitor their progress and by the integration of the sport psychologist supporting athletes' adherence to the activities. Most of the participants were willing to recommend the app use for future athletes, and this positive response may be related to the feedback module the app provided, which made them aware of their own positive psychological change.

Tennis players shared several positive feelings about the experience and highlighted several benefits of the intervention both for their sport performance and for their well-being, such as effectiveness in relaxation and emotion management, in focused attention in several domains and in psychological well-being. Participants also positively evaluated the application, defining it as interesting, useful, well designed, simple and practical to use. Furthermore, participants expressed a preference regarding their favorite exercises. The most well-liked breathing exercise was "3-second square breathing" with 35% approval and the favorite relaxation exercise was "the Sea," a nature-based guided visualization, with 45% approval. Finally, considering the Perform-UP Tennis total score in user experience assessment and taking into account previous research conclusions obtained by accessing multiple mHealth apps with the original MARS [53], we can consider Perform-UP Tennis as a high-quality app. This app can be used to help the professional in giving continuity in training. It can also be easily integrated in physical preparation and daily routine training.

The limits of the present research can be identified in having used a passive control group, which may have led to overestimating the effects of the intervention. Therefore, new research could be possibly carried out with a group of tennis players using a generic application of relaxation or breathing (e.g., Headspace or Calm) and a group using Perform-UP Tennis, which is, instead, highly sport-specific and specifically designed for tennis, comparing and evaluating any changes in sports performance. In addition, only some weeks of the mental training program in the app were tested and not all. Therefore, it would be interesting to repeat the research and test all the weeks this time, to then assess the extent of changes in promoting athletes' mindfulness and self-esteem and reducing in anxiety when completing the entire program.

To conclude, this blended intervention has shown good results in just a few weeks and opens the door to future studies that could integrate the potential of new technologies in promoting the well-being of athletes and their performance.

Abbreviations

PST	Psychological Skills Training
MT	Mindfulness Training
MAC	Mindfulness-Acceptance-Commitment
MBI	Mindfulness-based interventions

PT	Positive Technology
IPPS-48	Inventario Psicologico della Prestazione Sportiva (Psychological Inventory of Sport Performance)
MIS	Mindfulness Inventory for Sport
MARS	Mobile Application Rating Scale

Acknowledgements
Not applicable.

Author contributions
The Perform-UP Tennis app was developed by S.B. and G.C helped write the breathing and mindfulness protocols within it. In addition, G.C. conducted the interviews with the athletes who took part in the research project. D.V. edited the methodological part of the research project and tables. S.B. and G.C. wrote the main manuscript text. All authors reviewed the manuscript.

Funding
Not applicable.

Data availability
The data that support the findings of this study are available from the corresponding author, S.B., upon reasonable request.

Declarations

Ethics approval and consent to participate
This study has been conducted in compliance with the Declaration of Helsinki and approved by the Local Ethics Committee of Psychology Department of Università Cattolica del Sacro Cuore di Milano, Italy (CERPS) (Reference Number: 42 – 21). All adult athletes and parents of junior athletes filled in and signed an informed consent form before beginning the research about the research protocol, data protection and privacy according to the General Data Protection Regulation (GDPR; EU 2016/679). The study's objectives, confidentiality, and anonymity were described, and volunteers were given full authority to complete the study. All methods were performed in accordance with the relevant guidelines and regulations in the declaration - Ethics approval and consent to participate section.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 29 November 2023 / Accepted: 29 April 2025
Published online: 21 May 2025

References

1. Lochbaum M, Stoner E, Hefner T, Cooper S, Lane AM, Terry PC. Sport psychology and performance meta-analyses: A systematic review of the literature. PLoS ONE. 2022;17(2).
2. Röthlin P, Horvath S, Trösch S, Birrer D. Differential and shared effects of psychological skills training and mindfulness training on performance-relevant psychological factors in sport: a randomized controlled trial. BMC Psychol. 2020;8(1):1–13.
3. Weinberg RS, Gould D. Foundations of sport & exercise psychology. 6th ed. Champaign, IL: Human Kinetics; 2015.
4. Gardner FL, Moore ZE. The psychology of enhancing human performance: the mindfulness-acceptance-commitment (MAC) approach. New York: Springer Publishing Company; 2007.
5. Segal ZV, Teasdale JD, Williams JM, Gemar MC. The mindfulness-based cognitive therapy adherence scale: Inter-rater reliability, adherence to protocol and treatment distinctiveness. Clin Psychol Psychother. 2002;9(2):131–8.
6. Röthlin P, Birrer D, Horvath S, Grosse Holtforth M. Psychological skills training and a mindfulness-based intervention to enhance functional athletic performance: design of a randomized controlled trial using ambulatory assessment. BMC Psychol. 2016;4:1–11.
7. Burg JM, Michalak J. The healthy quality of mindful breathing: associations with rumination and depression. Cognit Ther Res. 2011;35(2):179–85.
8. Hopper SI, Murray SL, Ferrara LR, Singleton JK. Effectiveness of diaphragmatic breathing for reducing physiological and psychological stress in adults: a quantitative systematic review. JBI Database Syst Rev Implement Rep. 2019;17(9):1855–76.
9. Zaccaro A, Piarulli A, Laurino M, Garbella E, Menicucci D, Neri B, et al. How breath-control can change your life: a systematic review on psycho-physiological correlates of slow breathing. Front Hum Neurosci. 2018;12:353.
10. Clini E, Bianchi L, Foglio K, Vitacca M, Ambrosino N. Exhaled nitric oxide and exercise tolerance in severe COPD patients. Respir Med. 2002;96(5):312–6.
11. Mamassis G, Doganis G. The effects of a mental training program on juniors pre-competitive anxiety, self-confidence, and tennis performance. J Appl Sport Psychol. 2004;16(2):118–37.
12. Dohme LC, Bloom GA, Piggott D, Backhouse S. Development, implementation, and evaluation of an athlete-informed mental skills training program for elite youth tennis players. J Appl Sport Psychol. 2020;32(5):429–49.
13. Howells A, Ivtzan I, Eiroa-Orosa FJ. Putting the 'app' in happiness: a randomised controlled trial of a smartphone-based mindfulness intervention to enhance wellbeing. J Happiness Stud. 2016;17(1):163–85.
14. Renn BN, Hoeft TJ, Lee HS, Bauer AM, Areán PA. Preference for in-person psychotherapy versus digital psychotherapy options for depression: survey of adults in the US. NPJ Digit Med. 2019;2(1):1–7.
15. Mrazek AJ, Mrazek MD, Cherolini CM, Cloughesy JN, Cynman DJ, Gougis LJ, et al. The future of mindfulness training is digital, and the future is now. Curr Opin Psychol. 2019;28:81–6.
16. Ryan RM, Weinstein N, Bernstein J, Brown KW, Mistretta L, Gagne M. Vitalizing effects of being outdoors and in nature. J Environ Psychol. 2010;30(2):159–68.
17. McDaid D, Hewlett E, Park AL. Understanding effective approaches to promoting mental health and preventing mental illness. 2017.
18. Sassi R, Cerutti S, Lombardi F, Malik M, Huikuri HV, Peng CK, et al. Advances in heart rate variability signal analysis: joint position statement by the e-Cardiology ESC working group and the European heart rhythm association co-endorsed by the Asia Pacific heart rhythm society. Europace. 2015;17(9):1341–53.
19. Lyubomirsky S, King L, Diener E. The benefits of frequent positive affect: does happiness lead to success? Psychol Bull. 2005;131(6):803.
20. Botella C, Riva G, Gaggioli A, Wiederhold BK, Alcaniz M, Banos RM. The present and future of positive technologies. Cyberpsychol Behav Soc Netw. 2012;15(2):78–84.
21. Riva G, Baños RM, Botella C, Wiederhold BK, Gaggioli A. Positive technology: using interactive technologies to promote positive functioning. Cyberpsychol Behav Soc Netw. 2012;15(2):69–77.
22. Villani D, Cipresso P, Gaggioli A, Riva G. Integrating technology in positive psychology practice. Hershey, PA: IGI Global; 2016.
23. Gaggioli A, Villani D, Serino S, Banos R, Botella C. Positive technology: designing e-experiences for positive change. Front Psychol. 2019;10:1571.
24. Flett JA, Conner TS, Riordan BC, Patterson T, Hayne H. App-based mindfulness meditation for psychological distress and adjustment to college in incoming university students: a pragmatic, randomised, waitlist-controlled trial. Psychol Health. 2020;35(9):1049–74.
25. Wasil AR, Palermo EH, Lorenzo-Luaces L, DeRubeis RJ. Is there an app for that?? A review of popular apps for depression, anxiety, and Well-Being. Cognit Behav Pract; 2021.
26. Bhavnani SP, Narula J, Sengupta PP. Mobile technology and the digitization of healthcare. Eur Heart J. 2016;37(18):1428–38.
27. Kellmann M, Bertollo M, Bosquet L, Brink M, Coutts AJ, Duffield R, et al. Recovery and performance in sport: consensus statement. Int J Sports Physiol Perform. 2018;13(2):240–45.
28. Kittler C, Stenzel L, Jekauc D, Stoll O. Implementation of an App-Based blended mindfulness intervention in a Bundesliga youth academy targeting goalkeepers: A case study. Case Stud Sport Exerc Psychol. 2021;5(1):95–105.
29. Carissoli C, Gasparri D, Riva G, Villani D. Mobile well-being in pregnancy: suggestions from a quasi-experimental controlled study. Behav Inf Technol. 2021:1–13.
30. Mani M, Kavanagh DJ, Hides L, Stoyanov SR. Review and evaluation of Mindfulness-Based iPhone apps. JMIR Mhealth Uhealth. 2015;3(3).
31. Stenzel L, Röcken M, Borgmann S, Stoll O. Developing and implementing an app-based blended psychological skills training: A case study. Sport Psychol. 2021;35(2):155–67.
32. Torous J, Wisniewski H, Liu G, Keshavan M. Mental health mobile phone app usage, concerns, and benefits among psychiatric outpatients: comparative survey study. JMIR Ment Health. 2018;5(4).

33. Lozano-Lozano M, Fernández-Lao C, Cantarero-Villanueva I, Noguerol I, Álvarez-Salvago F, Cruz-Fernández M et al. A blended learning system to improve motivation, mood State, and satisfaction in undergraduate students: randomized controlled trial. J Med Internet Res. 2020;22(5).
34. Villani D, Caputo M, Balzarotti S, Riva G. Enhancing self-efficacy through a blended training: A pilot study with basketball players. Int J Sport Exerc Psychol. 2017;15(2):160–75.
35. Bilić Z, Dukarić V, Šanjug S, Barbaros P, Knjaz D. The concurrent validity of mobile application for tracking tennis performance. Appl Sci. 2023;13(10):6195.
36. Walsh KM, Saab BJ, Farb NA. Effects of a mindfulness meditation app on subjective well-being: active randomized controlled trial and experience sampling study. JMIR Ment Health. 2019;6(1).
37. Busch L, Utesch T, Bürkner PC, Strauss B. The influence of fitness-app usage on psychological well-being and body awareness—a daily diary randomized trial. J Sport Exerc Psychol. 2020;42(3):249–60.
38. Sin NL, Lyubomirsky S. Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: A practice-friendly meta-analysis. J Clin Psychol. 2009;65(5):467–87.
39. Nguyen J, Brymer E. Nature-based guided imagery as an intervention for state anxiety. Front Psychol. 2018;1858.
40. Buchanan TL, Janelle CM. Emotions and ensuing motor performance are altered by regulating breathing frequency: implications for emotion regulation and sport performance. Front Psychol. 2022;13:963711.
41. Grecucci A, Pappaianni E, Siugzdaite R, Theuninck A, Job R. Mindful emotion regulation: exploring the neurocognitive mechanisms behind mindfulness. Biomed Res Int. 2015.
42. Robazza C, Bortoli L, Gramaccioni C. L'inventario psicologico Della prestazione sportiva IPPS-48. G Ital Psic Sport. 2009;4:14–20.
43. Thienot E, Jackson B, Dimmock J, Grove JR, Bernier M, Fournier JF. Development and preliminary validation of the mindfulness inventory for sport. Psychol Sport Exerc. 2014;15(1):72–80.
44. Domnich A, Arata L, Amicizia D, Signori A, Patrick B, Stoyanov S, et al. Development and validation of the Italian version of the mobile application rating scale and its generalisability to apps targeting primary prevention. BMC Med Inf Decis Mak. 2016;16(1):1–10.
45. Birrer D, Röthlin P, Morgan G. Mindfulness to enhance athletic performance: theoretical considerations and possible impact mechanisms. Mindfulness. 2012;3(3):235–46.
46. Walker SP. Mindfulness and burnout among competitive adolescent tennis players. S Afr J Sports Med. 2013;25(4):105–8.
47. Barton RA, Capellini I. Maternal investment, life histories, and the costs of brain growth in mammals. Proc Natl Acad Sci U S A. 2011;108(15):6169–74.
48. Maturo A, Setiffi F. The gamification of risk: how health apps foster self-confidence and why this is not enough. Health Risk Soc. 2016;17(7–8):477–94.
49. Nichols S. A recipe for meaningful gamification. Gamification in education and business. Cham: Springer; 2015. pp. 1–20.
50. Tod D, Andersen MB. Success in Sport Psych: Effective Sport Psychologists. The sport psych handbook. 2005;305– 12.
51. Clarke J, Draper S. Intermittent mindfulness practice can be beneficial, and daily practice can be harmful. An in depth, mixed methods study of the calm app's (mostly positive) effects. Internet Interv. 2020;19:100293.
52. Laurie J, Blandford A. Making time for mindfulness. Int J Med Inf. 2016;96:38–50.
53. Bardus M, van Beurden SB, Smith JR, Abraham C. A review and content analysis of engagement, functionality, aesthetics, information quality, and change techniques in the most popular commercial apps for weight management. Int J Behav Nutr Phys Act. 2016;13(1):1–9.

Publisher's note