Title: The Association Between Mindfulness and Mental Health Outcomes in Athletes: Testing the Mediating Role of Autonomy Satisfaction as a Core Psychological Need.

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Abstract

Mindfulness may improve well-being through increasing one's ability to self-regulate stressors, which are common and multifaceted among the student-athlete population. However, the mechanisms for influencing such effects lacks a theoretical basis. Therefore, we sought to: (i) determine the relationship between mindfulness, well-being and stress in student-athletes, and: (ii) to assess the mediating role of autonomy satisfaction, an innate psychological need required for optimal well-being according to Self-Determination Theory. This was a cross-sectional study of 240 student-athletes (aged 20.5; SD=3.29; 53.7% males). Mindfulness and autonomy were regressed onto well-being (Model 1) and stress (Model 2) in multivariate regression models assessing direct and indirect mediating mechanisms. More than a third of athletes scored low on well-being, and only 3% high, and a significant proportion of variance was explained in both models (Model 1: R^2= .40; Model 2: R^2= .37). Mindfulness directly predicted autonomy satisfaction (β=.42, p <.001), well-being (β=.26, p <.001), and stress (β=-.21, p <.001). Autonomy satisfaction also directly predicted well-being (β=.47; p <.001) and stress (β=-.48; p <.001), whilst partially mediating the association between mindfulness and well-being (indirect β=.19) and stress (indirect β=-.20). To conclude, mindfulness may improve well-being and reduce stress through increasing athletes' capacity to self-regulate, satisfying the psychological need for autonomy. Future research may consider designing a controlled trial of mindfulness interventions for student-athletes, underpinned and tested using SDT.

Keywords: meditation; self-determination theory; psychology; health; sport

Background

Well-being is one dimension of a two continua model of mental health (Keyes, 2005), and defined as a state of optimal functioning (Ryan & Deci, 2017) characterised by psychological (e.g., a sense of purpose, realising one's potential), emotional (i.e., positive affective states, reduced negative affect) and social (i.e., relationships) dimensions. Well-being reliably produces positive mental health states (e.g., flourishing) (Keyes, 2005) and reduces incidences of mental illness (Huppert, 2009). In contrast, stress arises when demands on an individual exceed their personal resources and capacity to cope (Steptoe, 1997), and is inversely related to well-being (Gu, Strauss, Bond, & Cavanagh, 2015). The student-athlete (or collegiate athlete) population are at risk of experiencing multiple sporting, academic and social stressors (discussed below) and subsequent mental health issues (Gavrilova, Donohue & Galante, 2017). Indeed, student-athletes demonstrate a higher clinical and sub-clinical risk for behavioural issues than non-athletes (e.g., substance misuse, eating disorders, gambling; Moreland, Cox & Yang, 2017), and most data indicate that student-athletes are at least as likely as non-athletes, or in some cases more likely, to experience mood disorders (Donohue et al., 2018). As such, there is consensus that innovative approaches to mental health promotion are required for the student-athlete population (Breslin, Shannon, Haughey, Donnelly & Leavey, 2017; Schinke, Stambulova, Si, & Moore, 2018; Moesch et al., 2018).

Student-athletes experience co-existing academic, social and sporting demands (Wilson & Pritchard, 2005; Bennet, 2007). For example, many student-athletes live away from home, and undergo academic assessment expectations, financial stressors and uncertain career prospects (Pitt, Oprescu, Tapia, & Gray 2017; Sudano, Collins & Miles, 2017) on top of sport participation. Surveys also indicate that sport competition demands (e.g., physical and technical preparation) negatively impact upon student-athletes' social life and relationships (Wilson & Pritchard, 2005), with some equating sporting participation to working in two full-time jobs (Bennet, 2007). As such, through feeling pressure to perform in

both academic and sporting pursuits, student-athletes report having a constrained social life and relationship difficulties (Abedalhafiza, Altahaynehb & Al-Haliqc, 2010; Gavrilova et al., 2017). Furthermore, due to the physical and often aggressive nature of sport, student-athletes are likely to sustain injury, and experience emotional and physical fatigue from competition and over-training (Putukian, 2015). When not managed appropriately, the presence of such multifaceted stressors can result in impaired functioning and maladaptive coping (e.g., gambling, substance misuse) (Moreland et al., 2017). Collectively, the above evidence highlights the need for mental health self-management strategies.

Mental health self-management is defined as an ability to self-monitor how one's mental health is impacting upon personal functioning, and use of strategies that protect and promote mental health (Wolf, 1996; Shannon et al., 2019a). However, many student-athletes report that they do not have the awareness and knowledge required to self-manage mental health (Eisenberg, Golberstein & Gollust, 2007; Hunt & Eisenberg, 2010). One self-management intervention that is receiving increasing cultural support among athletes is mindfulness (Noetel, Ciarrochi, Van Zanden, & Lonsdale, 2017). Mindfulness is defined by Brown and Ryan (2003) as being attentive to and aware of present events and experiences. The benefits of mindfulness to mental health are diverse (Creswell, 2017), with a variety of interventions helping individuals alleviate depression and anxiety symptoms, and improve emotional well-being (Chiesa & Serretti, 2011; Keng, Smoski & Robins, 2011; Creswell, 2017). Mindfulness may also help individuals direct motivations and intentions into health behaviour change (Chatzisarantis & Hagger, 2007).

Mindfulness is increasingly being used in sport psychology (Noetel et al., 2017) on the basis that mindfulness improves sport-related mental states among athletes (e.g., reducing performance anxiety, improving flow) (Sappington & Longshore, 2015). However, despite the advent of several recent position and consensus statements on athlete mental health

(Reardon, Hainline, Aron, Baron, Baum & Bindra, 2019; Breslin et al., in press; Schinke, Stambulova, Si, & Moore, 2018; Moesch et al., 2018), a systematic review established that mindfulness studies in sport have focused on performance-related outcomes, with few centered on mental health (Noetel et al., 2017). Furthermore, of the few mental health studies that have been conducted (e.g., Vidic, Martin & Oxhandler, 2017; Vidic, Martin & Oxhandler, 2017), there has been little attention to the precise mechanisms driving the effects of mindfulness on mental health outcomes.

To ascertain how mindfulness may relate to improved mental health, theoretical constructs can be modelled to study the indirect effect of a predictor variable (*X*) on an outcome (*Y*) through one or more mediating variables (*M*) (Kok, Schaalma, Ruiter, Van Empelen & Brug, 2004). Through Self-Determination Theory (SDT), Ryan & Deci (2000) contend that satisfaction of one's innate psychological need for autonomy is an essential requirements for optimal well-being. Autonomy satisfaction is defined as having volitional actions or beliefs that are self-endorsed by the individual (Ryan & Deci, 2000), and research indicates that autonomy satisfaction is related to mental health outcomes and self-management behaviours (Ryan & Deci, 2017). Whilst SDT's other core psychological needs of competence (i.e., sense of effectiveness) and relatedness (i.e., sense of belonging) needs satisfaction are relevant to mental health self-management (Wolf, 1996), autonomy satisfaction has a particularly close theoretical alignment, such that when one's need for autonomy is satisfied, one experiences a sense of personal volition regarding their selection of mental health-related behaviours (e.g., help-seeking), through to endorsing values (e.g., importance of mental health) at a high level of awareness (Ryan & Deci, 2017). From a SDT perspective it is well established that socio-environmental support can facilitate psychological needs satisfaction. Yet, mindfulness is also viewed as an internal support mechanism that individuals can avail of to satisfy basic needs such as autonomy (Weinstein

& Ryan, 2011; Ryan & Deci, 2017), yet such hypotheses lacks comprehensive empirical inquiry.

In SDT it is proposed that autonomy satisfaction can be supported by mindfulness, insofar as mindful states provide individuals with a greater awareness of ongoing events and subsequent purposeful selection of need-satisfying experiences (Campbell et al. 2015; Campbell et al., 2017) that is consistent with one's values, motives and interests (Brown & Ryan, 2003; Schultz et al., 2015). In contrast, less mindful individuals are assumed to have a reduced capacity to satisfy their need for autonomy and self-regulate their actions, making them more reactive or impulsive under controlled conditions, resulting in subsequent needs frustration (Brown, Ryan & Cresswell, 2007). Scant research has examined the association with mindfulness and autonomy satisfaction however (Parto & Besharat, 2011), with only one study to our knowledge among athletes; (Chang, Chang, & Chen, 2018). Both aforementioned studies supported the mechanism that autonomy satisfaction mediated the relationship between mindfulness with psychological well-being. However with replication being a cornerstone of the scientific method in prevention science (Valentine et al., 2011), further research is required to determine sufficient rigor in the understanding of the mindfulness and mental health relationship. Furthermore , those studies included a sample of 717 seventeen year old at-risk students not involved in competitive sport (Parto & Besharat, 2011), or among Eastern athletes (Chang et al., 2018) which raises the methodological issue of extrapolable of the data to Western athletes (Schumaker & Lomax, 2004), particularly given the cultural prevalence and acceptance of meditative practices in Eastern populations, that is not as evident in Western populations (Cresswell, 2017) Furthermore, stress which is a significant factor implicated in mental health (Huppert, 2009; Gu, Strauss, Bond, & Cavanagh, 2015), has yet to be studied in current SDT research on mindfulness, suggesting a gap in current theoretical understanding.

Hence, in response to recent consensus statements (Schinke et al., 2018; Breslin et al., in press) that innovative and theoretically-driven approaches are required for athlete mental health promotion, the present study sought to understand the role of mindfulness in promoting well-being and reducing stress among student-athletes, through the mediating role of autonomy satisfaction. The findings will contribute to theoretical advancement of SDT, and towards evidence-based recommendations for mental health promotion among the student-athlete population.

Study hypotheses

In accordance with SDT hypotheses (Ryan & Deci, 2000; see Figure 1 below) and extant mindfulness research applying SDT (Chang et al., 2018), two models were tested assessing (1) well-being, and (2) stress as dependent variables (*Y*), with mindfulness as the independent variable (*X*) and autonomy satisfaction (*M*), as the mediating variable.

In Model 1, mindfulness was hypothesised to directly and positively predict well-being (Hypothesis 1; H_{1a}) and autonomy satisfaction (Hypothesis 2; H_2). Autonomy satisfaction was also hypothesised to directly and positively predict well-being (Hypothesis 3; H_3). Given mindfulness may exert a direct and indirect link to well-being through a variety of biopsychosocial self-regulatory mechanisms (Brown & Ryan, 2000; Brown et al., 2007; Gu et al., 2015), the link between mindfulness and well-being was hypothesised to be partially, rather than fully mediated through autonomy satisfaction (Hypothesis 4; H_{4a}). In Model 2, all of the above hypotheses were repeated (H_{1b}, H_2, H_3, H_{4b}), replacing well-being with stress as the dependent variable, and each of the relationships predicting stress were hypothesised to be negative.

Please insert Figure 1*: Multivariate regression model assessing direct and indirect association between mindfulness (X) on well-being/stress (Y) through autonomy satisfaction*

(M).

Method

Study design, size, setting and participants

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were adopted (see von Elm, Altman, Egger, Pocock, Gøtzsche, Vandenbroucke, et al., 2007). Ethical approval was granted from Ulster University. Data collection was conducted in the institution through online SurveyMonkey software. Inclusion criteria was based on students reporting 'yes' to the following question consistent with the definition of sport, 'Are you an athlete involved in a structured, competitive physical activity?' (Rejeski & Brawley, 1988).

Variables and measurement

Demographic variables

Two hundred and forty student-athletes took part. The mean age of the sample was 20.50 years (SD=3.29), 57.3% percent were males and 42.7% were females. A broad range of sports were represented in the sample, with the most common being Gaelic Sports (42%), Football (22.5%), Rugby (5.8%), Hockey (5.1%), Basketball (3.6%), Netball (2.9%), Irish Dancing (2.9%), and other sports (15.2%; e.g., Athletics, Combat, Rowing).

Mindfulness

The Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003) was used to measure mindfulness disposition. The MAAS is a 15-item scale constructed through a uni-dimensional factor, designed to assess an individual's attention to, and awareness of, day-to-day internal and external experiences. An example item is: 'I could be experiencing some emotion and not be conscious of it until some time later'. A 6-point Likert scale scoring method ranging from 'almost always' (1), to 'almost never' (6) is used, wherein higher scores

reflect higher mindfulness. Several studies have demonstrated the validity and reliability of the MAAS, including support for a unidimensional factor structure (Brown & Ryan, 2003; MacKillop & Anderson, 2007), including those in sport with athlete samples (Araya-Vargas et al., 2009). Cronbach's alpha within the present sample was .88.

Autonomy satisfaction

The Perceived Choice and Awareness of Self Scale (PCASS), or as formerly labeled the 'Self-Determination Scale' (Sheldon, Ryan & Reis, 1996), was used to measure autonomy satisfaction, specifically to the degree of volition one experiences over their behaviours and sense of self. The PCASS is a 10-item measure with items scored on a 5-point Likert scale on a structured alternative format. Participants selected if 'only A feels true' (1 point) through to 'only B feels true' (5 points). The PCASS is a valid and reliable measure of autonomy satisfaction (Sheldon et al., 1996; Thrash & Elliot, 2002). An example item includes: 'A. I always feel like I choose the things I do', or 'B. I sometimes feel that it's not really me choosing the things I do'. The PCASS has been psychometrically tested with athletic populations (Mouratidis & Michou, 2011). Cronbach's alpha within the present sample = .82.

Well-being

The Warwick-Edinburgh Mental Well-being Scale (WEMWBS; Tennant et al., 2007) was used to assess student-athletes' levels of well-being. The WEMWBS is a valid and reliable tool for measuring well-being (Tennant et al., 2007; Stewart-Brown et al., 2011), and has been used extensively in athletic populations (Appelqvist-Schmidlechner et al., 2018). Cronbach's alpha analysis yielded .90 within the present sample. The measure comprises 14-items through a uni-dimensional factor structure, with statements designed to measure both hedonic (e.g., happiness and life satisfaction), social (i.e., relationships) and eudemonic (i.e., self-actualisation) well-being components. Each item is positively worded and scored on a 5-

point Likert scale ranging from ‘none of the time’ (1), to ‘all of the time’ (5). Total scores can range from 14 through to 70, with higher scores indicating higher well-being. Previous research (Fat et al., 2017) has established three well-being profiles from the measure scores, including ‘low’ (i.e., 14–42); ‘medium’ (i.e., 43–60) and ‘high’ (i.e., 61–70).

Stress

The Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein,, 1994) was used to measure student-athlete’s appraisal of stress in day-to-day experiences. The PCSS is constructed through a uni-dimensional factor, and includes 10-items, each scored on a 5-point Likert scale ranging from 0 ‘never’ to 4 ‘very often’. The PCSS demonstrates excellent psychometric properties across a range of samples including students (Roberti, Harrington & Storch, 2006; Lee, 2012).The PSS has been tested in mindfulness intervention studies with athletes (Vidic, Martin & Oxhandler, 2017), and Cronbach’s alpha was high (.83) within the present sample. Scoring methodology for the PCSS (Cohen et al., , 1994) indicates a uni-dimensional structure, with a total score reflecting stress levels, and lower scores indicate less stress.

Statistical methods and bias

Data management

Raw scores were transferred into Statistical Package for Social Sciences (SPSS version 22). Two researchers inspected the data set for outliers. For each scale, Little’s Missing Completely at Random (MCAR; Little, 1988) was conducted to determine if missing data was in random order. MCAR analyses revealed the data was indeed missing at random ($p > .05$), with missing responses ranging between 2-5%. Subsequently, the Expectation Maximisation (EM) algorithm was conducted on each individual scale, using inter-correlated items for estimating missing values (Field, 2013).

Data analyses

Descriptive statistics were calculated for each scale, with mean scores and standard deviations produced. A correlation matrix was produced for each of the outcome variables. Low, moderate and high well-being profiles were created based on the scoring methodology for the WEMWBS (Tennant et al., 2007).

Hayes' (2015) PROCESS macro for SPSS was used to test the study hypotheses (see Figure 1). To produce standardised beta coefficient (β) values, all variables were standardised as z-scores. In Model 1, mindfulness was specified as the independent variable (*X*), and regressed onto autonomy satisfaction (*M*) and well-being (dependent variable; *Y*). In Model 2, stress replaced well-being as the dependent variable (*Y*; depicted in Figure 1). To examine indirect relationships, a bootstrapping technique was conducted with 5000 samples to improve model accuracy and parameter reliabilities (Byrne, 2001). Results show if the relationship between *X* and *Y* is (i) non-significant; (ii) direct with non-mediation (i.e mediator does not influence relationship); (iii) fully meditated (i.e. direct effect is no longer significant after controlling for mediators' effect); (iv) partially mediated (i.e. direct effect is significant alongside an indirect effect) or, (v) indirect (i.e. no direct effect, but significant indirect effects: Hayes, 2009). Associations between the variables were determined statistically significant ($p < .05$) on the basis of confidence intervals not crossing zero (Field, 2013). Two figures were produced to visually illustrate Model 1 and 2 (see Figures 3 & 4 respectively), including completely standardised beta (β) coefficient values for each direct path, and R^2 values for proportion of total predicted variance in the model on the dependent variable, mediators and the R^2 mediated effect size.

Results

Outcome data

Mean scores and standard deviations for psychometric scales are presented in Table 1. Categorisation of the sample based on well-being scores showed that 35% of participants scored low, 62% medium, and 3% high.

Please insert Table I: *Mean scores, correlation matrix and Cronbach's alpha values for the study outcomes.*

Main results

Model 1: Well-being as the dependent variable

Results from Model 1 indicated that mindfulness (*X*) significantly and directly predicted autonomy satisfaction (*M*; β=.42, p <.001, 95% CI's = [.304 to .506]; R^2= .18), and well-being (*Y*; β=.26, p <.001, 95% CI's = [.158 to .377]), supporting H_{1a} and H_2. In support for H_3, autonomy satisfaction also directly and positively predicted well-being (*Y;* β= .47, p <.001, 95% CI's = [.361 to .580]). When exploring the indirect relationship between mindfulness and well-being through autonomy satisfaction, analyses revealed that while the direct relationship remained significant, indirect associations were also present, suggesting partial mediation through autonomy satisfaction. Specifically, and in support for H_{4a}, mindfulness (*X*) in sequence with autonomy satisfaction (*M*) resulted in a significant indirect association with well-being (*Y*; β=.19, 95% CI's= [.120 to .289]), and an R^2 mediated effect size of .16. Factoring in all of the variables in Model 1 resulted in a significant proportion of variance predicted for well-being (R^2= .40). See Figure 2 for a visual description of Model 1, including specific β coefficients for significant paths.

Model 2: Stress as the dependent variable

Results from Model 2 were aligned with Model 1, to the extent that mindfulness (*X*) significantly and directly positively predicted autonomy satisfaction (*M*; β=.42, p <.001, 95%

CI's = [.304 to .506]; R^2= .18), and in this case, negatively predicted stress (*Y*; β=-.21, *p* <.001, 95% CI's = [-.330 to -.105]), supporting H_{1b} and H_2. Autonomy satisfaction also directly and negatively predicted stress (*Y*; β=-.48, *p* <.001, 95% CI's = -.594 to -.370), supporting H_3. When exploring H_{4b}, specifically regarding the indirect association between mindfulness and stress through autonomy satisfaction, analyses revealed partial mediation. Specifically, the direct path remained significant, but mindfulness (*X*) in sequence with autonomy satisfaction (*M*) resulted in a significant indirect association with stress (β=-.20, *p* <.001, 95% CI's= [-.282 to -.141]), and an R^2 mediated effect size of .14. Factoring in all of the variables in Model 2 resulted in a significant proportion of variance predicted for stress (R^2= .36). See Figure 3 for a visual description of Model 2, including specific beta coefficients for significant paths.

Please insert Figure 2: *Model 1 showing the relationship between mindfulness (X) and well-being (Y) through autonomy satisfaction (M).*

Please insert Figure 3: *Model 2 showing the association between mindfulness (X) and stress (Y), through autonomy satisfaction (M).*

Discussion

This study was in response to calls that theoretically-driven research is needed for improved understanding of athlete mental health (Schinke et al., 2018; Moesch et al., 2018; Breslin et al., 2019). As such, mindfulness was examined as a predictor of mental health outcomes including stress and well-being, with autonomy satisfaction derived from SDT (Ryan & Deci, 2000) used as a theoretical lens to understand the underlying mechanisms between mindfulness and mental health. As one of the pioneering mindfulness studies to incorporate SDT (Ryan & Deci, 2000) among a sporting population at-risk of mental health challenges (Shannon et al., 2019b), our study makes a number of contributions to the literature, specifically through outlining the indirect mechanisms driving the salutary associations

between mindfulness and mental health (Creswell, 2017). Overall, a significant proportion of variance was explained in both models (Model 1: R^2= .40; Model 2: R^2= .37), with results supporting the study hypotheses. Specifically, mindfulness predicted well-being and stress ($H_{1a,b}$), and autonomy satisfaction (H_2); autonomy satisfaction predicted well-being and stress (H_3), and; autonomy satisfaction partially mediated the association between mindfulness and the mental health outcomes of well-being and stress ($H_{4a,b}$). Taken collectively, the findings are of theoretical value to the mechanisms of mental health promotion through mindfulness, and are now discussed in relation to practical and theoretical considerations in further work.

As well-being is a key component of mental health (Keyes, 2002), it was notable that just 3% of the sample scored high, in contrast to the 35% that scored low and 62% at medium in the WEMWBS (Tennant et al., 2007). To provide context to these figures, comparisons with a UK sample (n = 27,169) using the same measures (Fat et al., 2017), suggests lower well-being among student-athletes than the general population who scored 15% (low), 71% (medium), and 14% (high). The significant proportion of the sample (35%) reporting low well-being is of concern, particularly given that low well-being increases the likelihood of mental illnesses (Keyes, 2005; Huppert, 2009). Likewise, on average student-athletes reported higher stress levels (M: 18.13) than various demographic groups in a sample based in the United States (US; Cohen & Janicki-Deverts, 2012), including those in unemployment (M: 16.46). As such, it was of empirical value to test predictors of well-being and stress in the present study.

Results of Model 1 and Model 2 showed that mindfulness directly predicted well-being and stress ($H_{1a,b}$). Given that the direct effects of mindfulness on well-being and stress remained significant in the model after accounting for the mediating influence of autonomy satisfaction, i.e., partial rather than full mediation (discussed below), mindfulness may have unique associations with mental health beyond psychological needs satisfaction. For

example, there are proposals that mindfulness improves somatic experiences which leads to greater positive effect, and less negative affect (Brown et al., 2007; Hölzel et al., 2011), and mindfulness results in better cognitive appraisal and reductions in rumination (Gu et al., 2017). Moreover, mindfulness may increase one's likelihood to convert intentions into health behaviours that promote well-being, such as physical activity (Chatzarantis & Hagger, 2007).

Most relevant to our findings however, as the mindfulness construct has been shown to mediate effects of mindfulness programmes on mental health outcomes (Gu et al., 2015), it is worth aiming to effectively engage athletes with mindfulness practices to possibly improve mindfulness dispositions. Such provision may be better received when athletes feel the intervention is sensitive to the nuances of sports culture (Gavrilova et al., 2017). Examples like this can be seen in the Mindfulness-Acceptance-Commitment Programme (MACP; Gardner & Moore, 2004), which has been linked with both positive sporting and mental health outcomes (Gardner & Moore, 2007; Gross et al., 2018; Zhang, Chung, Si, & Gucciardi, 2016; Perry et al., 2017). Beyond the aforesaid direct associations between mindfulness and mental health outcomes, the present study sough to delve further into the mechanisms driving the salutary role of mindfulness.

Specifically, results of Model 1 and Model 2 showed that mindfulness directly and positively predicted autonomy satisfaction (H_2). These findings lend support to the view that beyond interpersonal factors, mindfulness can act as mechanism from within which may satisfy one's innate psychological need for autonomy (Schultz et al., 2015; Ryan & Deci, 2017). Specifically, the data support the hypotheses that mindfulness may facilitate a mental state that is attentive to the present, which helps individuals remain reflective to ongoing internal (e.g., strong emotions) and external (e.g., demanding tasks) prompts. Subsequently, athletes may be able to make dispassionate, autonomy-satisfying decisions during demanding and stressful experiences (Campbell et al. 2015; Campbell et al., 2017). For instance, a coach

may demand that their team behave aggressively during a sporting competition in orderto intimidate other competitors, despite such behavior being inconsistent with many of the individual team members' autonomous values. Importantly, Schultz et al. (2014) have outlined that in these cases, mindful and less mindful athletes within the team will experience similar levels of autonomy frustration, however, the more mindful athletes will be more resilient to the control over their autonomy, and self-regulate and cope more effectively. Therefore, as autonomy satisfaction has been evidenced to be a core characteristic of healthy human functioning (Schultz et al., 2015; Ryan & Deci, 2017), cultivating mindfulness through meditative practices may have added value in increasing the likelihood of adaptive responses to the multiple stressors faced by student-athletes in sporting (e.g., injury, performance), social (e.g., peers) and academic (e.g., assessment demands) pursuits (Gross et al., 2018).

As mindfulness can be enhanced during short (Rosenkranz, Dunne, & Davidson, 2019) and longer-term (Cayoun, 2011; Creswell, 2017) interventions, it may be worth aiming to effectively engage athletes with a range of mindfulness programmes for improving basic needs fulfillment. However, while most SDT theorists propose that the mindfulness construct precedes autonomy satisfaction, in addition to competence and relatedness satisfaction (e.g., Brown et al., 2007; Schultz et al, 2015), it is worth raising the point that, in a temporal sense, the relationship between mindfulness and needs satisfaction has been mixed. For instance, some authors (Olfan, 2017; Shannon et al., 2019b) have found empirical support forneeds satisfaction preceding the mindfulness construct, and thus may produce the energy to enable one to focus on the present. Whereas, others suggest that mindfulness is the precursor to needs satisfaction (Schultz et al, 2015; Chang et al., 2018). The cross-sectional nature of the present research study permits testing the temporal order of these events, and therefore,

future longitudinal intervention studies may consider this open question, which is of theoretical value.

Models 1 and 2 demonstrated that autonomy satisfaction positively predicted well-being, and negatively predicted stress (H_3). The data therefore supports SDT hypotheses (Ryan & Deci, 2000), and a cogent body of research that autonomy satisfaction is robustly related to positive mental health (Sheehan, Herring & Campbell, 2018). While the present study supports the view that mindfulness be explored as a potential facilitator of autonomy satisfaction (Ryan & Deci, 2017), the multitude of interpersonal factors influencing student-athletes' sense of autonomy satisfaction should not be discounted. For example, the provision of input into sporting, social and academic matters by coaches (Ntoumanis, Quested, Reeve, & Cheon, 2017), peers (Moreland et al., 2017) and university tutors (Pitt, et al., 2017) may be as significant, or indeed more so, as mindfulness to student-athletes basic needs fulfillment. Thus, both intra and interpersonal support mechanisms should be considered in the context of mental health provision for student-athletes.

The mediating role exerted by autonomy satisfaction in the mindfulness and well-being and stress relationship ($H_{4a,b}$) supports the SDT perspective (Brown & Ryan's, 2003; Weinstein & Ryan, 2011) and empirical evidence (Chang, Huang & Lin, 2015; Chang, et al., 2018) that the fulfillment of basic psychological needs can mediate the effects of mindfulness on mental health outcomes. Examined through the lens of eudemonic (e.g., realising one's potential), emotional (i.e., positive affective states, reduced negative affect) and social (i.e., relationships) well-being dimensions, through mindfulness an athlete may be more capable of recognizing injury and ill-being symptoms stemming from their sporting participation (Gustafsson, Skoog, Davis, Kenttä & Haberl, 2015). In this example, an athlete might experience ongoing pressures from their coaching staff to continue training and competing under injury. However, the more mindful athlete may understand such attempts to control

their autonomy, and instead, decide to seek medical attention based upon the best interests of their mental and physical health, and sporting performance (Gross et al., 2018). Being better informed and reflective to such somatic information has been shown to prevent ill-being, and promoting longer-term wellness (Creswell, 2017). In contrast, with acting without mindfulness, an athlete may continue competing through painful injury, and despite achieving short-term introjected approval, struggle with the negative long-term effects on their health and sporting participation, sometimes resulting in burnout and withdrawal from their sport (Gustafsson et al. 2015).

Lastly, the present study was the first among athletes to evidence that autonomy satisfaction mediated the relationship between mindfulness and stress (H_{4b}). In a practical sense, when student-athletes develop improved awareness through mindfulness, this may reduce stress through self-regulation, such that attention can be directed to behaviours and coping mechanisms that fulfil their needs, values and interests (Brown & Ryan, 2003). For example, athletes could draw upon mindfulness to satisfy their autonomy in social contexts that are controlling and stressful in nature, wherein peers may provoke them to display values (e.g., hedonistic) and behaviours (e.g., drug use) inconsistent with their basic need for autonomy (Reb, Narayanan, & Ho, 2015). Given mindfulness is characterized by a non-judgmental and open attention to the present, such athletes may be less likely to introject external values, or ruminate over whether to engage with approval-seeking behaviours (Creswell et al., 2007; Weinstein, Brown & Ryan, 2009).

The key contribution of the current study was the integration of SDT (Ryan & Deci, 2000) into a predictive model of student-athletes mindfulness and mental health, who remain an understudied sporting population at-risk of mental health challenges (Shannon et al., 2019a). The findings provide several theoretical and practical considerations. For instance, the link found between mindfulness and mental health outcomes indicates that practitioners

may consider a proactive attempts to engage athletes with mindfulness interventions, whilst also paying attention to the remaining open questions regarding access and potential risks (see Creswell, 2017). Further, as autonomy satisfaction was found to mediate the association between mindfulness and well-being and stress, further research may consider integrating components of SDT into a mindfulness intervention to help determine the precise mechanisms of well-being promotion through mindfulness. Such work may consider assessing the temporal order of the mindfulness-needs satisfaction relationship, and be rigorously tested through a longitudinal, controlled study design. Despite these contributions, our study is not without its limitations. One limitation was that we could not infer causality from the data because of the cross-sectional design, and additional SDT components (i.e., competence and relatedness satisfaction) were absent from the models. A future recommendation is that studies adopt a longitudinal experimental design with additional SDT components that consider these limitations.

To conclude, recent position statements (Schinke et al., 2018; Moesch, Kenttä, Kleinert, Quignon-Fleuret, Cecil & Bertollo, 2018; Breslin et al., in press) have indicated that theoretically-driven mental health research is needed among athletes. Therefore, the present study assessed the role of mindfulness in predicting well-being and stress in student-athletes through autonomy satisfaction, an innate psychological need according to SDT. Study hypotheses were supported, and the findings have led us to suggest that more mindful student-athletes may act with an awareness which may reduce stress and improve well-being through mechanisms reflective of autonomy satisfaction. To this end, mindful student-athletes may have a greater volitional capacity, in the sense that their attention can be directed to behaviours and coping mechanisms during times of stress, that can fulfil their needs, which may ultimately result in positive mental health (Brown & Ryan, 2003). As such, attempts to engage athletes with mindfulness interventions may be considered , with caution

to be given to the remaining open questions regarding accessibility and potential risks (Creswell, 2017). From a theoretical, practical and research standpoint, SDT may be considered in the design and evaluation of mindfulness interventions, in which researchers may consider employing a longitudinal controlled research design.

Declaration of interest statement

All authors declare no conflict of interest. This research adhered to the ethical principles of the declaration of Helsinki. All participants provided informed consent prior to their involvement in the study.

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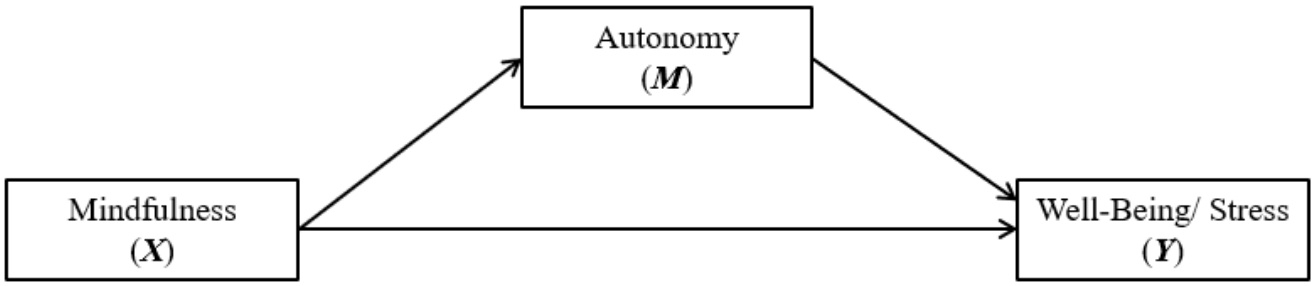
List of figures

739 Figure 3: Model 2 showing the effect of mindfulness (X) on stress (Y), through autonomy
740 (M).

741

742 **Figure 1**: Multivariate regression model assessing direct and indirect effects of mindfulness

743 (*X*) on well-being/stress (*Y*) through autonomy satisfaction (*M*).

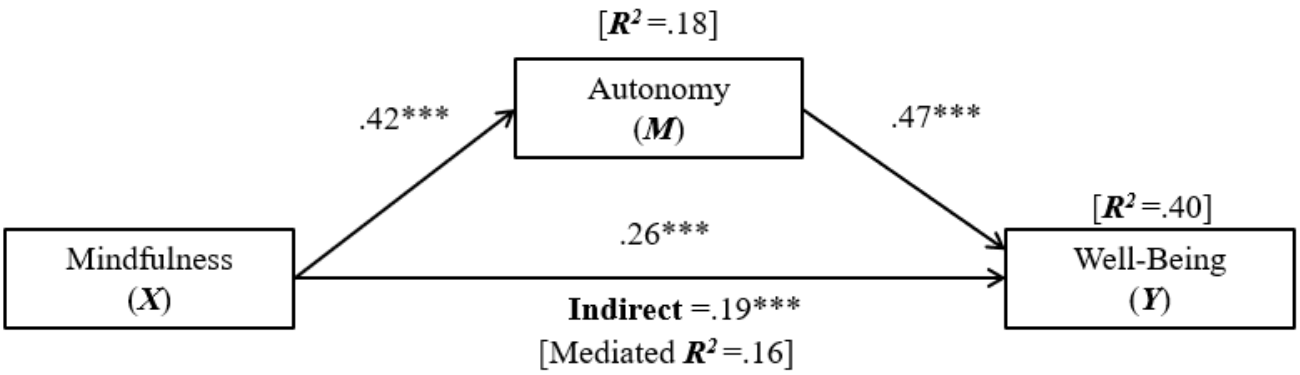


744

Note: H4 refers to the indirect effect of mindfulness (X) on well-being/stress (Y) through autonomy (M); each relationship predicting stress is hypothesized to be negative.

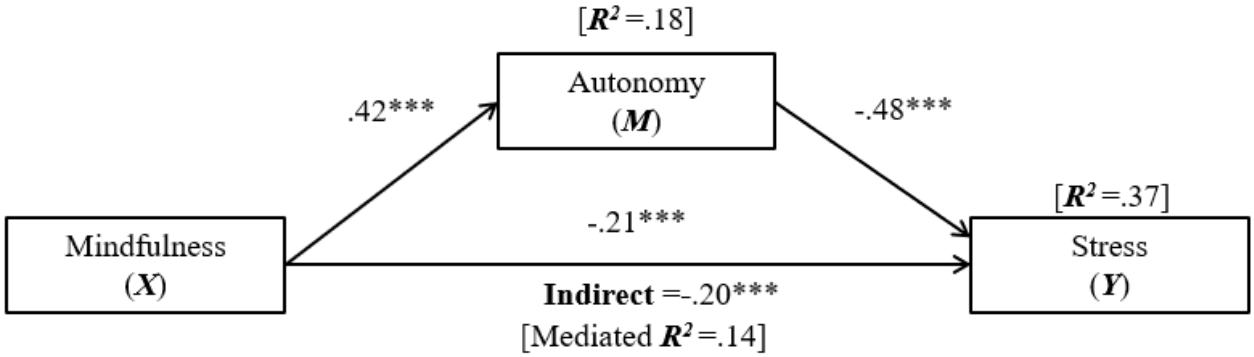
745

746 **Figure 2:** Model 1 showing the effect of mindfulness (X) on well-being (Y) through
747 autonomy satisfaction (M).



748 **Note:** *=p<.05; **=p<.01; ***=p<.001.
749
750

751 **Figure 3:** Model 2 showing the effect of mindfulness (X) on stress (Y) through autonomy
752 satisfaction.



753 **Note:** *=p<.05; **=p<.01; ***=p<.001.

754

755

Table I: Correlation matrix, Cronbach's alpha (α) internal consistency values, mean scores and standard deviations (SD) for the study outcomes

	Mindfulness	Autonomy	Well-being	Stress
Mindfulness	1			
Autonomy	.42*	1		
Well-being	.47*	.58*	1	
Stress	-.42*	-.57*	-.72*	1
Cronbach's α	.88	.82	.90	.83
Sample mean and SD	54.91 (11.95)	37.32 (7.31)	44.63 (7.73)	18.13 (.36)

Note: standard deviations in brackets; * denotes statistical significance at $p < .001$

Key points
• Student-athletes can be prone to mental health difficulties, including high levels of stress and multiple sporting, academic and personal demands. • Our study found that mindfulness may facilitate autonomy satisfaction, which consistent with Self-Determination Theory, predicted improved well-being and reduced stress, and mediated the relationship between mindfulness and well-being, and mindfulness and stress. • Practitioners and researchers may consider designing and evaluating Self-Determination Theory-based mindfulness interventions for student-athletes, which could ultimately improve autonomy satisfaction and mental health outcomes.

760