European Journal of Sport Science

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tejs20

Mindfulness and shooting performance in biathlon. A prospective study

Torbjörn Josefsson , Henrik Gustafsson , Trym Iversen Rostad , Frank L. Gardner & Andreas Ivarsson

To cite this article: Torbjörn Josefsson , Henrik Gustafsson , Trym Iversen Rostad , Frank L. Gardner & Andreas Ivarsson (2020): Mindfulness and shooting performance in biathlon. A prospective study, European Journal of Sport Science, DOI: 10.1080/17461391.2020.1821787

To link to this article: https://doi.org/10.1080/17461391.2020.1821787

Published online: 12 Oct 2020.

European Journal of Sport Science, 2020
https://doi.org/10.1080/17461391.2020.1821787

ORIGINAL ARTICLE

Mindfulness and shooting performance in biathlon. A prospective study

TORBJÖRN JOSEFSSON[1], HENRIK GUSTAFSSON[2], TRYM IVERSEN ROSTAD[3], FRANK L. GARDNER[4], & ANDREAS IVARSSON [1]

[a]*Center of Research on Welfare, Health, and Sport, Halmstad University, Halmstad, Sweden;* [b]*Faculty of Health, Science, and Technology, Karlstad University, Karlstad, Sweden;* [c]*Department of Coaching & Psychology, Norwegian School of Sport Sciences, Oslo, Norway &* [d]*Department of Advanced Studies in Psychology, Kean University, Hillsdale, NJ, USA*

ABSTRACT
The aim of the study was to examine the temporal relationship between facets of sport-specific dispositional mindfulness (i e., Awareness, Refocusing, Nonjudgemental attitude) and shooting performance in actual competitions, in a population of 25 elite biathlon athletes. Findings indicated that mindfulness facets were positively associated with shooting performance, with higher levels of Awareness, Refocusing, and Awareness being related to better shooting performance in competitions. In spite of the fact that the explained variance was quite small, even a minor shooting performance enhancement may increase an athlete's chance of winning a biathlon competition.

Keywords: *Performance, competition, psychology, quantitative study*

Highlights
- Dispositional athletic mindfulness facets (Awareness, Refocusing, Nonjudgemental attitude) were all credible predictors of shooting performance.
- The participants reported fairly high levels of dispositional athletic mindfulness.
- Biathlon experience was a credible predictor of shooting performance whereas competitive level was not.

"I glide into the stadium for the last shoot and hear the crowd's roars. Then my thoughts drift away. You start thinking about what will happen after the shoot. The thoughts just flutter off. But 99% of those thoughts are way too positive. I can't manage just being in the present moment but instead shoot a terrible bout" (Larsson, Flinck, & Norberg, 2019).

The citation above is from the women's 2019 World Championship in biathlon. In an interview after the race, Swedish athlete Mona Brorsson described that she was in the lead by 20 s and had just one shoot left but missed four shots in the last bout. Instead of winning the gold medal, Brorsson finally ended up in the seventh place. This is an example of the small margins in elite sports and the importance of being focused in order to perform optimally. Biathlon is a very complex sport that places great demands on both physiobiomechanical factors as well as psychophysiological processes. Shooting under high physical load while under stress also requires advanced attentional skills (Laaksonen, Finkenzeller, Holmberg, & Sattlecker, 2018). Mindfulness techniques are often associated with improved attention regulation abilities (e.g. Chiesa, Calati, & Serretti, 2011; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010) that are hypothesized to help athletes stay focused on current sport task-relevant stimuli (e.g. Gardner & Moore, 2012; Josefsson et al., 2019) Table I.

Mindfulness is often defined as "paying attention in a particular way: on purpose, in the present moment and nonjudgementally" (Kabat-Zinn,

Correspondence: Torbjörn Josefsson, Center of Research on Welfare, Health, and Sport, Halmstad University, Kristian IV:s väg 3, Halmstad 301 18, Sweden. E-mail: torbjorn.josefsson@hh.se

Table I. Comparison of the two specified models.

	Model A	Model B
Within-person level		
Variance shooting performance	31.20 [1.55, 95.38]	30.25 [1.32, 93.56]
Between-person level		
Variance shooting performance	30.76 [1.41, 95.59]	30.40 [1.38, 91.93]
Performance level	−0.12 [−0.73, 0.52]	−0.12 [−0.71, 0.50]
Years in biathlon	0.15 [0.07, 0.46]	0.15 [0.07, 0.46]
Awareness – Performance		0.02 [0.01, 0.08]
Refocusing - Performance		0.03 [0.01, 0.10]
Non-judgmental attitude-Performance		0.03 [0.01, 0.11]
Model fit indices		
PPp [95% Confidence Interval]	0.33 [−8.89, 15.59]	0.41 [−12.13, 15.06]
DIC	155	152
Variance explained		
R^2	0.08	0.09

1994, p. 4). According to the Monitor and Acceptance Theory (MAT; Lindsay & Creswell, 2017), the concept of mindfulness involves two interacting components: (i) attention to and awareness of present internal and external stimuli, and (ii) acceptance. The combination of enhanced awareness/attention abilities and acceptance is hypothesized to explain health-related effects due to mindfulness practice. Particularly, improved attention skills and acceptance of distressing stimuli may reduce stress, enhance performance on cognitive tasks, and diminish affective reactivity (Lindsay & Creswell, 2017).

Birrer, Röthlin, and Morgan (2012) developed a theoretical model where they suggest that mindfulness practice and/or self-rated mindfulness (trait mindfulness) lead to a number of particular mindfulness impact mechanisms (e.g. acceptance, attention regulation) that, in turn, may improve psychological sport-specific skills (e.g. coping, cognitive skills). Enhancements in sport-relevant psychological skills may then improve athletic performance (Birrer et al., 2012). Moreover, greater attention regulation abilities may require fewer cognitive resources, which should make it easier for athletes to stay focused on present sport tasks in both competition and practice (Gardner & Moore, 2012; Marks, 2008).

Meta-analytical results show large effect sizes in favour of mindfulness- and acceptance based interventions (MABI) compared to control conditions on athletic performance outcomes ($d = 1.35$), psychological performance surrogate variables ($d = 0.72$), and physiological performance surrogate variables ($d = 3.62$) (Bühlmayer, Birrer, Röthlin, Faude, & Donath, 2017). Further, the majority of correlational analyses indicate that self-rated mindfulness is positively related to both objective sport performance (Gooding & Gardner, 2009; Thompson, Kaufman, De Petrillo, Glass, & Arnkoff, 2011) and subjective athletic performance (e.g. Josefsson et al., 2019; Röthlin, Horvath, Birrer, & Holtforth, 2016). On the other hand, Noetel, Ciarocchi, Sahdra, and Lonsdale (2019) found only weak relations between sport-specific mindfulness and putting performance in golf, in a population of non-competitive golfers. Mindfulness has also been associated with increases in performance-related variables such as athletic coping (Josefsson et al., 2017), flow (Kaufman, Glass, & Arnkoff, 2009), as well as reductions in competition anxiety (Röthlin et al., 2016). Overall, these results suggest that applying mindfulness skills in sport competitions may be related to athletic performance enhancement.

In general, very little research has been conducted on athletic performance in actual sport competitions (Hopkins, Hawley, & Burke, 1999; Martin, Vause, & Schwartzman, 2005). Several researchers (e.g. Martin et al., 2005; Pyne, Trewin, & Hopkins, 2004) recommend that athletic performance should be studied in actual sport competitions in elite athlete populations, and be assessed by objective, direct performance measures. Actual competition settings often differ substantially from practice as well as competitive tasks in laboratory based environments in a number of ways (e.g. behaviour of coaches as well as of other athletes, the physical environment, level of the athlete's arousal) (Martin et al., 2005). Only a few studies, however, have investigated effects of MABIs on objective sport competition performance outcomes but preliminary results suggest that performance is better for MABI participants compared to control conditions (Bernier, Thienot, Codron, & Fournier, 2009; John, Verma, & Khanna, 2011; Solberg, Berglund, Engen, Ekeberg, & Loeb, 1996). For example, Bernier et al. (2009), who studied golfers during both training sessions and competitions, showed that all golfers in the

MABI-group improved their national ranking. Additionally, the MABI participants also achieved their defined personal competition goals for the season (Bernier et al., 2009). Solberg et al. (1996) found that elite rifle shooters who participated in a meditation intervention increased their competition season scores the season after the intervention, compared to an inactive control group. Similarly, in a study by John et al. (2011), elite pistol shooters who underwent a mindfulness intervention showed statistically significant within-group increases in shooting scores compared to a (non-defined) control group. Furthermore, an intervention consisting of relaxation training and specific shooting training, improved shooting performance for elite biathlon athletes compared to controls, suggesting that mindfulness-related techniques may be associated with enhanced shooting performance (Laaksonen, Ainegren, & Lisspers, 2011).

The aim of the present study was to study the temporal relationship between sport-specific mindfulness skills (measured at T1) and shooting performance in actual biathlon competitions (T2).

Methods

Participants

Thirty-nine competitive elite senior and junior biathlon athletes were recruited from 6 biathlon associations in Norway. Ten participants did not, however, complete any of the questionnaires. Four of the participants did not participate in any competitions during the study and were therefore excluded from the analysis. Thus, the remaining 25 participants (20 men and 5 women, mean age = 21, SD = 1.55) were included in the analysis. In this sample, thirteen men and three women were seniors, competing at the highest national level in Norway. Seven men and two women were juniors, competing in the 20–21 year old division, which is also the highest national level for that age group.

Procedure

Emails including a presentation of the study and an inquiry to let the athletes participate in a longitudinal study were sent to the coaches and Sports directors for seven biathlon associations, of which six of them agreed to participate. Written information about the study design and ethical aspects were given to all participants who were interested to take part in the study. Web-based questionnaires, measuring mindfulness, were administered by email to the participants. The questionnaire was available for the participants during a period of two weeks in December 2015 and January 2016. Shooting performance results were collected in four competitions at the Norway Cup 2016 (11 and 25 January). Competition results were obtained at the EQ Timing website. The study was reviewed and approved by the Norwegian Social Science Data Services ethical review board (45105/3/AH).

Measures

Sport competition performance. Sport performance was assessed by using total shooting scores (%) in the following biathlon competition formats: individual, sprint, super sprint, and mass start.

Biathlon skills. Competitive level was measured by calculating ranking in the National Biathlon cup, based on the three competitions that took place prior to the current study. *Biathlon experience* was assessed by number of years active in biathlon.

Mindfulness Inventory for sport (MIS). The MIS (Thienot et al., 2014) is a recently developed 15-item questionnaire, using a 6-point Likert scale (1 = not at all; 6 = very much), designed to assess aspects of sport-specific dispositional mindfulness, and consists of three subscales: (i) *Non-judgemental attitude,* defined as "the willingness to allow and accept one's internal experience as it occurs, without any attempt to judge and criticise oneself for experiencing these cognitions, emotions and bodily sensations" (Thienot et al., 2014, p. 74) ("When I become aware that I am thinking of the final result, I blame myself for not being focused on relevant cues for my performance"), (ii) *Awareness*, defined as "the ability to closely observe one's internal experience in the present moment" (Thienot et al., 2014, p. 74) ("I am aware of the thoughts that are passing through my mind"), and (iii) *Refocusing* "the ability to disengage from elaborative processing to remain focused or to quickly refocus on task-relevant cues" (Thienot et al., 2014, p. 74) ("When I become aware that I am thinking about how tired I am, I quickly bring my attention back to what I should focus on"). Hence, Non-judgemental attitude reflects the acceptance component in MAT whilst the Awareness and Refocusing subscales reflect different elements of the attention monitoring component in MAT. Higher scores reflect greater perceived dispositional mindfulness in sport competitions.

Data analyses

All analyses were estimated with use of a Bayesian approach. One of the main differences between the Bayesian statistical approach and the more traditional frequentist approach is that it is based on different

statistical assumptions (for more information see, for example, Stenling, Ivarsson, & Lindwall, 2015). In comparison to the frequentist approach, the Bayesian approach has a better likelihood of producing reliable estimates with small sample sizes (Song & Lee, 2012). Due to the less restrictive distributional assumptions, the normality assumption does not need to be fulfilled to perform the analyses within the Bayesian approach (Yuan & MacKinnon, 2009).

To test the potential relationship between dispositional mindfulness skills and shooting performance on a two-level regression analysis were performed in Mplus 8.0 (Muthén & Muthén, 2017) using the Bayesian estimator. In the specification of the model, the shooting performance from each competition was specified on level 1. These scores were nested in athletes (level 2). The analyses were conducted in two steps. In the first step, a model with the two variables, competitive level and biathlon experience, were included as predictors of shooting on the between-person level (level 2). We decided to include these two variables because they are likely to influence shooting performance (Gooding & Gardner, 2009). Prior information for the structural path between these variables and shooting performance were obtained from two meta-analyses (i.e. Havriluk, 2005; Macnamara, Moreay, & Hambrick, 2016). Given the strength of evidence behind these two priors, moderate variance priors were specified (i.e. .01).

In the second step the three dispositional mindfulness variables were included, into the model with competitive level and biathlon experience, as predictors on the between-person level (the syntax file is available at: https://osf.io/pmws6/?view_only=9cfe903a5eb940c8a82d75b8393cce3a). Prior information for the structural path between dispositional mindfulness variables and shooting performance was obtained from a systematic review, summarizing studies aimed to investigate the relationship between mindfulness and athletic performance (Noetel, Ciarocchi, Van Zanden, & Lonsdale, 2017). Given the strength of evidence behind this prior, a moderate variance prior was specified (i.e. .01). To compare these two models (specified in step 1 and step 2) the deviance information criterion (DIC) was used. Explicitly, a lower value indicated a better-fitting model (Asparouhov, Muthén, & Morin, 2015).

An additional step was to, after determining what model that showed best fit to data, perform sensitivity analyses for each estimated model in order to investigate if changes in the prior variances (i.e. .001, .01, and .10) influenced the results. The DIC values for the different variance prior settings were used to compare the models.

In the analyses, we used the Markov Chain Monte Carlo simulation procedures with a Gibbs sampler. For all analyses, we performed 200,000 iterations. In line with previous recommendations, a potential scale reduction factor around 1 was considered as evidence of convergence (Kaplan & Depaoli, 2012). We assessed model fit using the posterior predictive p (PPp) value and its accompanying 95% confidence interval. In Mplus "the 95% confidence interval is produced for the difference in the f statistic for the real and replicated data. A positive lower limit is in line with a low posterior predictive *p* value and indicates poor fit" (Muthén & Asparouhov, 2012, p. 315). Default priors were used for all models.

We estimated credibility interval (CI) for all parameters estimated within the models. In comparison to the more traditional confidence interval the credibility interval indicates, the probability (e.g. 95%) that the parameter of interest, given the observed data, lies between the two values. The recommendations from Zyphur and Oswald (2015) were followed, meaning that we rejected the null hypothesis if the 95% CI did not include zero.

Results

Sport-specific dispositional mindfulness as a predictor of shooting performance

The participants had, on average, a shot accuracy of 81% ($SD = 7.93$) during the competitions. Mean and standard deviations of the dispositional mindfulness subscales: Non-judgemental attitude ($M = 3.46$, $SD = 0.90$), Awareness ($M = 4.75$, $SD = 0.60$), Refocusing ($M = 4.11$, $SD = 0.74$). The results from the model comparison showed that the model with the mindfulness variables included, showed better fit to data than the model in which only performance level and biathlon experience were included ($DIC_{Step1} = 155.12$, $DIC_{Step2} = 152.24$). Based on these results we decided to focus our presentation and discussion of the results from the model specified in step 2. Further, the sensitivity analyses showed that the model with a strong prior variance (.001) showed poorer fit to data in comparison to the two other models. The two other models showed better fit to data. Also, the DIC values as well as the direction of the effects were similar for these two models (with prior variance .01 and .1). Because the model with moderate variance priors (.01) showed less uncertainty regarding the parameter estimates, we decided to keep these within the analysis.

The selected model showed good fit to data (PPp = .41, 95% Confidence Interval [−12.13, 15.06]). The result showed credible variances for the shooting performance parameter on both within-person (level 1) as well as between-person level (level 2). The included predictors explained 9% of the variance in shooting performance. Biathlon experience ($\beta = .15$, 95% Credibility Interval [0.07, 0.46]), non-judgemental

attitude ($\beta = .03$, 95% Credibility Interval [0.003, 0.11]), awareness ($\beta = .02$, 95% Credibility Interval [0.003, 0.07]), and refocusing ($\beta = .03$, 95% Credibility Interval [0.004, 0.10]) had all positive credible associations with shooting performance. However, competitive level was not a credible predictor of shooting performance.

Discussion

The purpose of the present study was to examine the temporal relationship between sport-specific dispositional mindfulness and shooting performance in actual biathlon competitions on elite level. As expected, all the athletic mindfulness factors (awareness, non-judgemental attitude, refocusing) were credible predictors of shooting performance. Put differently, higher levels of sport-specific dispositional mindfulness factors at T1 were related to better shooting performance at T2. Additionally, biathlon experience was also a credible predictor of shooting performance whilst competitive level, unexpectedly, was not. A potential explanation for the lack of effect for competitive level on shooting performance could be that the biathlon athlete population is a fairly homogenous group where all the participants compete on the top level of biathlon in Norway. Given that skiing speed is a factor that is just as important for overall biathlon performance as shooting accuracy, previous competition rankings may not necessarily be specifically related to improvements in shooting, considering that it is, to some extent, possible to compensate poor shooting by superior skiing (Laaksonen, Jonsson, & Holmberg, 2018b).

Hence, the present study gives further support to previous correlational studies that also found positive relations between sport-specific mindfulness and objective athletic performance (i.e. Thompson et al., 2011). Biathlon athletes who have the capacity to inhibit distracting stimuli and also to quickly redirect attention to the current task when necessary (see Eysenck & Wilson, 2016), may arguably be better able to stay focused on each single task-relevant moment in shooting, despite experiencing stress and physical fatigue. Moreover, applying non-judging/acceptance skills on unwanted thoughts and emotions may require less cognitive resources than trying to get rid of them (Gardner & Moore, 2012; Marks, 2008). Furthermore, a non-judging attitude towards mental and emotional content may help athletes to refocus and thereby preventing them from directing attention back and forth between internal processes and external current sport-tasks. Hence, increases in both refocusing/attentional skills and non-judging/acceptance skills may help biathlon athletes from being distracted in the critical moment of shooting in a competition, and thereby making it easier for them to sustain attention on each step in the shooting procedure. Similarly, the results are also consistent with Birrer et al.'s (2012) theory of how mindfulness skills may enhance athletic performance. In the context of shooting in biathlon competitions, athletic mindfulness skills may enhance attention skills that in turn may lead to improved perceptual-cognitive skills. The non-judging component of athletic mindfulness may lead to fewer distractions caused by unexpected and/or potentially performance inhibiting experiences (e.g. negative thoughts, fear of failure or defeat) during a competition.

Acceptance and non-judging of various internal as well as external experiences may favour athletic performance by facilitating automatically learned fine motor skills in shooting without attentional disruptions (Birrer et al., 2012).

However, the explained variance specifically for the mindfulness factors as predictors of shooting performance was rather low (1%), indicating that other factors also influence shooting performance (e.g. within-person performance variation, competition experience, training programme, environmental conditions). Nevertheless, in the hard world of high-level competitive elite sport even a very small performance enhancement could mean the difference between winning a competition and ending up in the tenth place (Hopkins et al., 1999; Pyne et al., 2004). In essence, to win a medal in the Olympic Games, the biathlete cannot even miss one single shot (Laaksonen et al., 2018). As previously illustrated, Mona Brorsson was shooting for the gold medal in the last bout but missed four shots. According to her own explanations, it was her inability to inhibit distracting thoughts and to be present in the current moment that influenced her weak shooting performance in that bout, consequently resulting in a disappointing seventh place (Larsson et al., 2019). This example illustrates the importance of being able to sustain attention on the target (and refocus if attentional lapses occur) in shooting sports. In biathlon, each missed target results in a penalty loop of 150 m (except in individual racing where a penalty time of one minute is added to the final skiing time). Hence, considering the consequences of a missed shot in biathlon, even small improvements in dispositional mindfulness may reduce the number of missed targets, which indeed will have a crucial impact on the final results.

Limitations

There are several limitations that need to be addressed in the present study. First, self-report measures in general are more or less influenced by common

method biases (CMBs) (Podsakoff, MacKenzie, & Podsakoff, 2012). In an effort to reduce such biases, we followed the recommendations of Podsakoff et al. (2012) (i.e. obtaining data of the predictor and the criterion variable from different sources, and creating a temporal separation between the measurements of the predictor and the criterion variable). Second, mindfulness questionnaires in general have been criticized for several reasons: (i) it may be very difficult to rate to what extent one is mindful as well as "mindless", leading to a possible discrepancy between a person's true level of mindfulness and how mindful that person believes he/she is (Grossman & Van Dam, 2011), (ii) different mindfulness measures have been based on different operationalisations, targeting different populations, which has resulted in prominent differences between measures, such as a large variety of subscales, (Grossman & Van Dam, 2011; Quaglia, Brown, Lindsay, Creswell, & Goodman, 2015), (iii) the understanding of items may be largely dependent on previous meditation experience and/or familiarity with frequently used terms in MABIs (e.g. 'acceptance', 'nonjudging', 'paying attention') (Grossman & Van Dam, 2011). However, meta-analytical results show that mindfulness practice is positively correlated with increases in self-reported mindfulness subscales, and changes in these scales (e.g. attention, non-judgement) are in turn related to improvements in various mental health outcomes (e.g. depression, anxiety, quality of life) (Quaglia, Braun, Freeman, McDaniel, & Brown, 2016). Fourth, given the correlational nature of the design, the possibility to draw causal inference is limited. Hence, alternative models need to be considered (e.g. shooting performance leading to increases in sport-specific dispositional mindfulness). Fifth, the sample size was rather small. Thus, the generalizability may be limited. However, the entire population does not consist of more than approximately 200 elite biathlon athletes in Norwegian championships.

Conclusions

Athletic mindfulness skills may be a small but nonetheless crucial aspect of successful shooting performance in elite-level competitions for biathlon athletes. Considering that self-rated mindfulness often is increased after a MABI (see Bühlmayer et al., 2017), applying mindfulness- and acceptance based techniques may be beneficial for biathlon athletes for improving shooting performance in competitions. Future research should explore direct effects of a MABI (e.g. MAC) on objective shooting performance in biathlon competitions compared to a control condition. Additionally, proposed mechanisms such as emotion regulation (Josefsson et al., 2019; Moore, 2009; Moore, 2016) should also be examined in mediation models to further clarify indirect effects of MABI on shooting performance.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research project was supported by a grant from the Swedish Research Council for Sport Science [grant number D2016-0037/P2016-0146].

ORCID

ANDREAS IVARSSON http://orcid.org/0000-0002-8987-5975

References

Asparouhov, T., Muthén, B., & Morin, A. J. S. (2015). Bayesian structural equation modeling with cross-loadings and residual covariances: Comments on Stromeyer et al. *Journal of Management*, *41*, 1561–1577. doi:10.1177/0149206315591075.

Bernier, M., Thienot, E., Codron, R., & Fournier, J.F. (2009). A multi-study investigation examining the relationship between mindfulness and acceptance approaches and sport performance. *Journal of Clinical Sport Psychology*, *3*, 320–333.

Birrer, D., Röthlin, P., & Morgan, G. (2012). Mindfulness to enhance athletic performance: Theoretical considerations and possible impact mechanisms. *Mindfulness*, *3*, 325-246.

Bühlmayer, L., Birrer, D., Röthlin, P., Faude, O., & Donath, L. (2017). Effects of mindfulness practice on performance-relevant parameters and performance outcomes in sports: A meta-analytical review. *Sports Medicine*, *47*, 2309–2321. doi:10.1007/s40279-0170752-9.

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review*, *31*, 449-464. doi:10.1016/j.cpr.2010.11.003.

Eysenck, M. W., & Wilson, M. R. (2016). Sporting performance, pressure and cognition. Introducing attentional control theory: Sport. In D. Groome & M. W. Eysenck (Eds.), *An introduction to applied cognitive psychology* (2nd ed, pp. 329–350). New York: Routledge.

Gardner, F. L., & Moore, Z. E. (2012). Mindfulness and acceptance models in sport psychology: A decade of basic and applied scientific advancements. *Canadian Psychology*, *53*, 309-318.

Gooding, A., & Gardner, F. L. (2009). An investigation of the relation between mindfulness, preshot routine, and basketball free throw percentage. *Journal of Clinical Sports Psychology*, *4*, 303-319.

Grossman, P., & Van Dam, N. T. (2011). Mindfulness, by any other name … : trials and tribulations of Sati in Western psychology and science. *Contemporary Buddhism*, *12*, 219–239.

Havriluk, R. (2005). Performance level differences in swimming. A meta-analysis of passive drag force. *Research Quarterly for Exercise and Sport*, *76*, 112-118.

Hopkins, W. G., Hawley, J. A., & Burke, L. M. (1999). Design and analysis of research on sport performance enhancement. *Medicine & Science in Sports & Exercise*, *31*, 472-485.

John, S., Verma, S.K., & Khanna, G.L. (2011). The effect of mindfulness meditation on HPA-axis in pre-competition stress in sports performance of elite shooters. *National Journal of Integrated Research in Medicine*, *2*(3), 15–21.

Josefsson, T., Ivarsson, A., Gustafsson, H., Stenling, A., Lindwall, M., Tornberg, R., & Böröy, J. (2019). Effects of mindfulness-acceptance-Commitment (MAC) on sport-specific dispositional mindfulness, emotion regulation, and self-rated athletic performance in a multiple-sport population: An RCT study. *Mindfulness*, *8*, 1354–1363. doi:10.1007/s12671-019-01098-7.

Josefsson, T., Ivarsson, A., Lindwall, M., Gustafsson, H., Stenling, A., et al. (2017). Mindfulness mechanisms in sports: Mediating effects of rumination and emotion regulation on sport-specific coping. *Mindfulness*. doi:10.1007/s12671-017-0711-4.

Kabat-Zinn, J. (1994). *Wherever you go there you are*. New York, NY: Hyperion.

Kaplan, D., & Depaoli, S. (2012). Bayesian structural equation modeling. In R. H. Hoyle (Ed.), *Handbook of structural equation modeling* (pp. 650-673). New York, NY: The Guilford Press.

Kaufman, K.A., Glass, C.R., & Arnkoff, D.B. (2009). Evaluation of mindful sport performance enhancement (MSPE): A new approach to promote flow in athletes. *Journal of Clinical Sport Psychology*, *3*(4), 334–356.

Laaksonen, M. S., Ainegren, M., & Lisspers, J. (2011). Evidence of improved shooting precision in biathlon after 10 weeks of combined relaxation and specific shooting training. *Cognitive Behaviour Therapy*, *40*, 237-250. doi:10.1080/16506073.2011.616217

Laaksonen, M. S., Finkenzeller, T., Holmberg, H-C., & Sattlecker, G. (2018a). The influence of physiobiomechanical parameters, technical aspects of shooting, and psychophysiological factors on biathlon performance: A review. *Journal of Sport and Health Science*, *7*, 394-404. doi:10.1016/j.jshs.2018.09.003.

Laaksonen, M. S., Jonsson, M., Holmberg, H-C. (2018b). The Olympic biathlon – recent advances and perspectives in Pyeonchang. *Frontiers in Psychology*, *9*: 796. doi:10.3389/fphys.2018.00796.

Larsson, J., Flinck, J., & Norberg, L. (2019, March 10). Mona Brorsson sköt bort guldet. https://www.aftonbladet.se/sportbladet/a/A26pbM/mona-brorsson-skot-bort-guldet.

Lindsay, E.K., & Creswell, J.D. (2017). Mechanisms of mindfulness training: Monitor and acceptance theory (MAT). *Clinical Psychology Review*, *51*, 48–59. doi:10.1016/j.cpr.2016.10.011.

Macnamara, B. N., Moreay, D., & Hambrick, D. Z. (2016). The relationship between deliberate practice and performance in sports: A meta-analysis. *Perspectives on Psychological Science*, *11*, 333-350.

Marks, D. R. (2008). The Buddha's extra scoop: Neural correlates of mindfulness and clinical sport psychology. *Journal of Clinical Sport Psychology*, *2*, 216-241.

Martin, G.L., Vause, T., & Schwartzman, L. (2005). Experimental studies of psychological interventions with athletes in competition. Why so few? Behavior Modification, 29, 616-641. doi:10.1177/0145445503259394.

Moore, Z. E. (2009). Theoretical and empirical developments of the mindfulness-acceptance-Commitment (MAC) approach to performance enhancement. *Journal of Clinical Sports Psychology*, *4*, 291-302.

Moore, Z. E. (2016). Mindfulness, emotion regulation, and performance. In A. L. Baltzell (Ed.), *Mindfulness and performance, current perspectives in social and behavioral sciences* (pp. 29–52). New York: Cambridge University Press.

Muthén, B., & Asparouhov, T. (2012). Bayesian structural equation modeling: A more flexible representation of substantive theory. *Psychological Methods*, *17*, 317–335.

Muthén, L.K., & Muthén, B.O. (1998-2017). *Mplus User's Guide*. 8th ed. Los Angeles, CA: Muthén & Muthén.

Noetel, M., Ciarocchi, J., Sahdra, B., & Lonsdale, C. (2019). Using genetic algorithms to abbreviate the mindfulness Inventory for sport: A substantive-methodological synthesis. *Psychology of Sport and Exercise*, *45*, 101545. doi:10.1016/j.psychsport.2019.101545.

Noetel, M., Ciarocchi, J., Van Zanden, B., & Lonsdale, C. (2017). Mindfulness and acceptance approaches to sporting performance enhancement: A systematic review. *International Review of Sport and Exercise Psychology*, 139–175. doi:10.1080/1750984X.2017.1387803.

Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology*, *63*, 539–569. doi:10.1146/annurev-psych-120710-100452.

Pyne, D. B., Trewin, C. B., Hopkins, W. G. (2004). Progression and variability of competitive performance of Olympic swimmers. *Journal of Sport Sciences*, *22*, 613-620. doi:10.1080/02640410310001655822.

Quaglia, J. T., Braun, S. E., Freeman, S. P., McDaniel, M. A., & Brown, K. W. (2016). Meta-analytic evidence for effects of mindfulness training on dimensions of self-reported dispositional mindfulness. *Psychological Assessment*, *28*, 803-818. doi:10.1037/pas0000268.

Quaglia, J. T., Brown, K. W., Lindsay, E. K., Creswell, J. D., & Goodman, R. J. (2015). From conceptualization to operationalization of mindfulness. In K. W. Brown, J. D. Creswell, & R. M. Ryan (Eds.), *Handbook of mindfulness: Theory, research, and practice* (pp. 151–170). New York, NY: The Guilford Press.

Röthlin, P., Horvath, S., Birrer, D., & Holtforth, M. (2016). Mindfulness promotes the ability to deliver performance in highly demanding situations. *Mindfulness*, *7*, 727–733. doi:0.1007/s12671-016-0512-1.

Solberg, E. E., Berglund, K. A., Engen, O., Ekeberg, O., & Loeb, M. (1996). The effect of meditation on shooting performance. *British Journal of Sports Medicine*, *30*(4), 342-346.

Song, X.Y., & Lee, S.Y. (2012). *Basic and advanced Bayesian structural equation modeling: with applications in the medical and behavioural sciences*. Hoboken, NJ: Wiley. doi:10.1002/9781118358887.

Stenling, A., Ivarsson, A., & Lindwall, M. (2015). The only constant is change: Analysing and understanding change in sport and exercise psychology research. *International Review of Sport and Exercise Psychology*, *10*, 230–251.

Thienot, E., Jackson, B., Dimmock, J., Grove, R. J., Bernier, M., & Fournier, J. F. (2014). Development and preliminary validation of the mindfulness inventory for sport. *Psychology of Sport and Exercise*, *15*, 72-80. doi:10.1016/j.psychsport.2013.10.003.

Thompson, R.W., Kaufman, K.A., De Petrillo, L.A., Glass, C.R., & Arnkoff, D.B. (2011). One year follow-up of mindful sport performance enhancement (MSPE) with archers, golfers, and runners. *Journal of Clinical Sport Psychology*, *5*, 99–116.

Yuan, Y., & MacKinnon, D. P. (2009). Bayesian mediation analysis. *Psychological Methods*, *14*, 301–322.

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition*, *19*, 597–605. doi:10.1016/j.concog.2010.03.014.

Zyphur, M. J., & Oswald, F. L. (2015). Bayesian estimation and inference: A user's guide. *Journal of Management*, *41*, 390–420.