



Citation for published version:

Brown, DJ, Arnold, R, Standage, M & Fletcher, D 2021, 'A Longitudinal Examination of Thriving in Sport Performers', *Psychology of Sport and Exercise*, vol. 55, 101934.
<https://doi.org/10.1016/j.psychsport.2021.101934>

DOI:

[10.1016/j.psychsport.2021.101934](https://doi.org/10.1016/j.psychsport.2021.101934)

Publication date:

2021

Document Version

Peer reviewed version

[Link to publication](#)

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1 **Article accepted for publication in *Psychology of Sport and Exercise* on 10th March 2021**

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11 A Longitudinal Examination of Thriving in Sport Performers

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23 Date of resubmission: 8th March 2021

24 Date of initial submission: 6th July 2020

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1 Abstract

2 To sustain success in sport, athletes need to function effectively in their competitive
3 encounters and maintain this level over repeated events. Yet, to date, little is known about
4 how athletes can continue to fully function (i.e., thrive) in their sporting encounters. Equally,
5 there is a lack of research in relation to the factors that predict thriving. Testing the premise
6 that basic psychological needs (i.e., for autonomy, competence, and relatedness) predict
7 optimal functioning, the aim of this study was to provide the first longitudinal examination of
8 thriving in sport. Sport performers ($N = 268$) completed questionnaires assessing thriving and
9 basic psychological need satisfaction on three occasions across 28 days. Longitudinal
10 structural equation modeling showed thriving to be highly predicted by both the experience
11 of recent thriving and the perceived satisfaction of basic psychological needs. These findings
12 highlight an important mechanism through which coaches and practitioners can initiate and
13 maintain thriving in the athletes that they work with across a series of sporting encounters.

14 *Keywords:* basic psychological need satisfaction; performance; thrive; well-being.

1 A Longitudinal Examination of Thriving in Sport Performers

2 To sustain success in sport, athletes need to deliver high levels of performance in
3 competitive situations and repeat these levels over time. For example, performers will need to
4 produce multiple, high-level performances over consecutive weekends of a sport season or in
5 sequential daily rounds of a competition. Additionally, athletes' sporting success and their
6 experience of optimal functioning is governed by their continued, adaptive engagement with
7 these events via the experience of well-being (e.g., display of high levels of energy and vigor,
8 experience of positive mood; see Verner-Filion & Vallerand, 2018). Simultaneously
9 achieving both performance and well-being outcomes is reflective of the experience of
10 *thriving*, whereby the concurrent perception of high-level performance and experience of
11 high well-being in a specific encounter reflects the state-based form of the construct, and
12 their repeated occurrence across a series of encounters is purported to lead to sustained
13 development and success (Brown, Arnold, Fletcher, et al., 2017). Lending support to this
14 position, Brown et al. (2018) found that thriving in elite sport performers was perceived by
15 athletes, coaches, and sport psychology practitioners to comprise a sustained high-level of
16 performance and dimensions of well-being (e.g., sense of belonging, having an active
17 awareness, feeling optimistic). Understanding thriving therefore appears critical to addressing
18 what is deemed one of the most pressing and important issues in contemporary sport; that is,
19 to understand how athletes' performances can be enhanced while simultaneously optimizing
20 their well-being within highly demanding environments (Arnold & Fletcher, 2021; Fletcher,
21 2019).

22 A key feature of the construct of thriving is that it reflects the human experience of
23 functioning fully and holistically (see, Brown, Arnold, Fletcher, et al., 2017; Brown, Sarkar,
24 et al., 2020; Ryan & Deci, 2017; Su et al., 2014). From a self-determination theory (Ryan &
25 Deci, 2017) perspective, this fullness or holism represents one's collective access to the

1 faculties enabling awareness and true self-regulation, one's ability to mobilize and harness
2 psychological and physical energy for valued activities (i.e., vitality), as well as the
3 experience of positive subjective states (e.g., happiness; Ryan & Deci, 2017). The need for
4 this breadth of (positive) functioning indicators is also reflected in the work of Su et al.
5 (2014) who contend that "to thrive in life is not only marked by feelings of happiness, or a
6 sense of accomplishment, or having supportive and rewarding relationships, but is a
7 collection of all these aspects" (p. 272). Thus, to be thriving, one would be expected to
8 demonstrate high levels across multiple functioning indicators; critically, however, Brown,
9 Sarkar, et al. (2020) note that the dimensions of functioning used to determine thriving will
10 be contingent on the context (e.g., education, sport, work) and lens (e.g., context-specific vs.
11 life-general) being studied.

12 Within sport-based research, indicators of functioning have typically included hedonic
13 well-being (e.g., positive affect), eudaimonic well-being (e.g., psychological well-being,
14 vitality), and performance (e.g., perceived accomplishment; see, e.g., Gucciardi et al., 2017;
15 Verner-Filion & Vallerand, 2018), and scholars have begun to use these assessments to
16 identify individuals who have thrived (see, Brown, Arnold, Standage, et al., 2017; McNeill et
17 al., 2018). With a sample 535 sport performers, Brown, Arnold, Standage, et al. (2017)
18 assessed functioning using self-reported responses on subjective performance (via
19 performance satisfaction), eudaimonic well-being (via subjective vitality), and hedonic well-
20 being (via positive affect) and conducted factor mixture analysis to determine the shape and
21 level of functioning profiles. Their results demonstrated no shape effects, suggesting that all
22 performers could be described as having a tendency to report high (i.e., thriving), moderate
23 (i.e., above average or below average), or low scores (i.e., low functioning) across all
24 dimensions. Using cluster analysis, McNeill et al. (2018) found similar patterns in their work
25 with coaches, despite employing alternative positive and negative indicators of functioning

1 (i.e., personal accomplishment, emotional well-being, social well-being, psychological well-
2 being, emotional exhaustion, and depersonalization). Collectively, the results of Brown,
3 Arnold, Standage, et al. (2017) and McNeill et al. (2018) suggest that multiple indicators can
4 be used to measure functioning in sport and that these indicators can be modelled with a
5 single, global factor (i.e., functioning/thriving; see also, Brown, Arnold, et al., 2020;
6 Rouquette et al., 2021).

7 Armed with the knowledge that thriving can occur within sport and that it can be
8 determined using performers' subjective experiences of performance and well-being in
9 sporting encounters, researchers can now begin to examine the consequences of thriving,
10 along with the predictors of it. With regards to the consequences, an intriguing finding from
11 Brown et al.'s (2018) qualitative study was the description of both positive (i.e., personal
12 development and performance benefits) and negative (i.e., decreased mood/motivation)
13 outcomes following the occurrence of thriving in elite sport performers. This finding raises an
14 important question about whether experiencing thriving serves to promote or hinder future
15 thriving, and, ultimately, whether it can bring about sustained development and success as
16 previously suggested (see, Brown, Arnold, Fletcher, et al., 2017). Furthermore, Brown et al.
17 (2018) speculated that the timing of thriving may have transient or more enduring effects on
18 the positive and negative outcomes contingent on whether it occurred within the regular
19 season or in an encounter followed by a period of rest (e.g., off-season). More specifically,
20 they contend that thriving within the regular season may provide opportunities for
21 momentum, for a rebound in mood/motivation, and for initiating change, whereas thriving in
22 end-of-season encounters may result in a failure to capitalize on the positive experience or in
23 prolonged lethargy. With these hypotheses yet to be tested, conducting a quantitative
24 assessment of the lasting effects of thriving represents a critical next step in our knowledge of
25 the construct, as well as providing important insight for whether it is promoted and/or

1 managed.

2 Turning to the prediction of thriving, it is thought that humans possess universal and
3 basic needs which, when satisfied, can result in optimal functioning and thriving (Ryan &
4 Deci, 2017). These needs are considered basic given that growth, integrity, and well-being
5 depend on their satisfaction, that they bring about observable and meaningful positive
6 consequences for thriving, and that harm results from their deprivation or frustration (Deci &
7 Ryan, 2000; Ryan & Deci, 2017). While various candidate psychological needs have been
8 proposed (e.g., security, self-actualization-meaning; Sheldon et al., 2001), Ryan and Deci
9 (2017) argue that it is only the needs for autonomy (i.e., need for volitional, congruent, and
10 integrated functioning), competence (i.e., need to feel effectance and mastery), and
11 relatedness (i.e., need to feel socially connected and cared for) that meet these criteria. Each
12 of the needs are considered independently important, meaning that all three must be satisfied
13 for a person to be fully functioning; however, the needs are also highly interdependent and
14 intercorrelated, meaning that they are often reciprocally promoted and psychometrically
15 integrated into an overall need satisfaction score (Ryan & Deci, 2017). In sum, not only is
16 basic psychological need satisfaction predicted to relate to thriving, but the collective
17 satisfaction of these needs is proposed as “a necessary condition” for its occurrence (Ryan &
18 Deci, 2017, p. 242).

19 The role of basic psychological need satisfaction on the occurrence of thriving in
20 sport has been empirically examined within two studies to date. In the first of these studies,
21 Brown, Arnold, Standage, et al. (2017) examined the predictive effects of self-reported basic
22 psychological need satisfaction on sport performers’ membership to functioning profiles.
23 Their results showed need satisfaction to be a significant, positive predictor of performers’
24 membership to the “thriving” group when compared to the “above average” group, the
25 “below average” group, and the “low functioning” group. In the second study, Brown,

1 Arnold, et al. (2020) collected daily diary entries on players' perceptions of basic
2 psychological need satisfaction in advance of an important hockey match. In contrast to
3 previous research reporting daily fluctuations in autonomy, competence, and relatedness
4 satisfaction (see, e.g., Quested et al., 2013), daily levels were shown to be stable, with pre-
5 match levels positively predictive of in-match thriving. While both studies offer support for
6 the hypothesized relationship between basic psychological need satisfaction and thriving,
7 they are limited by their singular assessment of thriving as this precludes insight into whether
8 needs continue to act as a significant correlate of thriving over time. Moreover, although
9 scholars have demonstrated significant positive associations between early season need
10 satisfaction and end-of-season functioning indicators (e.g., subjective vitality; see Balaguer et
11 al., 2012, 2018), they are yet to examine the (direct or indirect) predictive effect on distal
12 occurrences of functioning indices or thriving beyond the immediate event. It is pertinent to
13 note that one mechanism for need satisfaction to impact future thriving may be via the
14 prediction of future need satisfaction, with researchers having previously found positive,
15 longitudinal relationships for basic psychological need satisfaction when examined across
16 two timepoints either as a whole (e.g., Balaguer et al., 2018) or the basic needs separately
17 (e.g., Reinboth & Duda, 2006). Establishing knowledge of the reliability and enduring nature
18 of these predictive effects is likely to offer significant insight to researchers wishing to
19 understand the theoretical mechanisms that underpin thriving, as well as to coaching, sport
20 science, and medical staff seeking robust frameworks on which to develop interventions to
21 promote their athletes' well-being alongside performance.

22 Therefore, in view of the aforementioned importance of thriving in sport, coupled
23 with the limited empirical research that exists on the enduring effect of thriving on
24 subsequent thriving and the relationship between basic psychological needs and thriving, the
25 aim for this study was to conduct the first longitudinal examination of thriving in sport. In

1 addition, this study aimed to provide the first replication assessment for the predictive effects
2 of basic psychological need satisfaction on thriving by looking at these effects on repeated
3 occasions. The study aims are unpacked through the following research questions and are
4 depicted via the regression paths displayed on Figure 1: (RQ1) Do previous levels of thriving
5 predict subsequent thriving? (RQ2) Do consistent predictive effects exist for basic
6 psychological need satisfaction on thriving over time? (RQ3) Do previous levels of basic
7 psychological need satisfaction directly or indirectly predict subsequent thriving?

8 **Method**

9 **Temporality of Variables and Study Design**

10 Inherent in the aims and research questions of this study were several implicit
11 assumptions regarding the temporality of the constructs (for a fuller discussion on
12 temporality, see George & Jones, 2000), which guided the longitudinal study design. First,
13 basic psychological need satisfaction and thriving were considered in state form whereby
14 their experience was bracketed for a specific sporting encounter (cf. Brown, Arnold, Fletcher,
15 et al., 2017). That is, it was assumed that each participant experienced a level of need
16 satisfaction and thriving that discretely begun and ceased as the encounter started and
17 finished, and that this experience could be captured by an overall ‘sporting encounter score’.
18 In so doing, we acknowledge that this ignored any momentary fluctuations that may have
19 occurred within the encounter by aggregating them into a singular, post hoc response.
20 Second, when measured over a broader time frame (e.g., a month), we anticipated that the
21 state-specific experiences of need satisfaction and thriving would be aggregated by
22 participants to offer an overall perception of their experiences. We recognize that this
23 aggregation may have been created evenly (i.e., each encounter perceived equally, and an
24 average experience of those encounters reported) or unevenly (i.e., specific encounters within
25 the timeframe given greater precedence than others). Third, we hypothesized that each

1 discrete experience of need satisfaction and thriving would have a predictive effect on future
2 occurrences grounded in the belief that previous behavior is the best predictor of the present
3 behavior on the same variable (Geiser, 2013); however, with little knowledge of the duration
4 of these relationships, we designed our study to test the predictive effects between adjacent
5 sporting encounters within the ‘regular season’. Furthermore, to examine the effect of the
6 level of time aggregation on this relationship we included both monthly and situation-specific
7 assessments.

8 **Participants**

9 Two hundred and sixty-eight sport performers (80 females) aged between 16 and 62
10 years ($M_{\text{age}} = 24.00$ years, $SD_{\text{age}} = 8.69$ years) participated in this study and represented a
11 subset of those previously sampled in the cross-sectional work of Brown, Arnold, Standage,
12 et al. (2017). The majority of participants (82.1%) were recruited from team sports (e.g.,
13 basketball, cricket, field hockey), but a variety of individual sports (e.g., archery, fencing,
14 horse riding) were also represented. Participants’ average competitive sporting experience
15 was 12.03 years ($SD = 7.44$). A range of competitive standards were identified with 2.2% of
16 performers reporting currently competing at an intracub level, 24.3% at a local level, 40.3%
17 at a regional level, 27.2% at a national level, 4.9% at an international level, and 0.4% as a
18 professional.

19 **Procedures**

20 All sport performers who previously took part in the work of Brown, Arnold,
21 Standage, et al. (2017; T1) were contacted 10 days after study completion to enquire whether
22 they would be willing to continue their involvement as a participant in a longitudinal study.
23 Participants were informed about the nature of the extended project and of their ethical rights
24 (e.g., confidentiality, anonymity, right to withdraw). Participation was voluntary, and consent
25 was required from adult participants or from coaches or teachers in loco parentis for sport

1 performers under the age of 18 years. The study involved participants completing two further
2 multi-section questionnaires (T2 and T3), which were available in both written and electronic
3 formats. The additional questionnaires were designed to be distributed at 14-day intervals, as
4 it was deemed likely that participants would have had subsequent sporting encounters within
5 this timeframe. In the follow-up questionnaires, participants were asked to reflect on their
6 experiences in a self-nominated sporting encounter within the two-week window; this was an
7 important difference to the data collected at T1 wherein participants were asked to reflect on
8 their general experiences in sporting encounters over the past month (see, Brown, Arnold,
9 Standage, et al., 2017). Reminder emails were sent to participants seven and 14 days after the
10 initial request, with the deadline for responses set as 21 days after the initial request;
11 therefore, the maximum allowable time between questionnaires was 35 days. These
12 additional days also afforded greater flexibility for participants who did not have a sporting
13 encounter within the initial 14-day window. Participants were excluded from the study if they
14 did not provide data for a minimum of two of the timepoints.

15 **Measures**

16 **Thriving.** To determine whether sport performers thrived in their encounters,
17 assessments of their subjective performance and well-being were provided (cf. Brown,
18 Arnold, Standage, et al., 2017). In accordance with existing work (e.g., Levy et al., 2011),
19 subjective performance was determined via the participant reporting their satisfaction with
20 their performance in their nominated sporting encounter (e.g., competition, match) on an 11-
21 point scale (0 = *totally dissatisfied*, 10 = *totally satisfied*; cf. Pensgaard & Duda, 2003).
22 Positive affect was used as a marker of hedonic well-being (cf. Kahneman et al., 1999) and
23 was assessed using the International Positive and Negative Affect Schedule Short Form (I-
24 PANAS-SF; Thompson, 2007). Specifically, participants reported the regularity with which
25 they experienced five emotional descriptors (e.g., inspired) during the encounter on a five-

1 point scale (1 = *never*, 5 = *always*). Cronbach's alpha values for the I-PANAS-SF ranged
2 from 0.66 to 0.77. Subjective vitality was used as an indicator of eudaimonic well-being (cf.
3 Ryan et al., 2008) and was assessed using a 4-item version of the Subjective Vitality Scale
4 (SVS; Ryan & Frederick, 1997). Specifically, participants responded to items assessing their
5 levels of aliveness and energy by judging the accuracy of the statements (e.g., *I had energy*
6 *and spirit*) in relation to their experience in the encounter on a six-point scale (1 = *not at all*
7 *true*, 6 = *very true*). Cronbach's alpha values for the SVS ranged from 0.87 to 0.90 in the
8 present study.

9 **Basic psychological need satisfaction.** Sport performers' levels of basic
10 psychological need satisfaction experienced in the nominated sporting encounter were
11 assessed using The Basic Needs Satisfaction in Sport Scale (Ng et al., 2011). Specifically,
12 performers responded to items measuring autonomy satisfaction (six items), competence
13 satisfaction (five items), and relatedness satisfaction (five items) on a seven-point scale (1 =
14 *not at all true*, 7 = *very true*). In the present study, Cronbach alpha scores ranged from 0.81 to
15 0.84 for the autonomy satisfaction scale, 0.88 to 0.92 for the competence satisfaction scale,
16 and 0.80 to 0.87 for the relatedness scale.

17 **Data Analysis Plan**

18 Analyses were conducted using SPSS 25 (IBM, 2017) and Mplus 8.4 (Muthén &
19 Muthén, 2019). All analyses in Mplus 8.4 were conducted using a maximum likelihood
20 estimation with robust standard errors to account for any non-normality within the data and
21 any missing values (Muthén & Muthén, 2015); Mplus syntax and outputs from all analyses
22 can be viewed in the Electronic Supplementary Resources.

23 **Data screening and preliminary analysis.** The data set was initially screened for
24 univariate outliers and missing values. Univariate outliers were determined using the
25 minimum and maximum scores on the raw data items. Missing value analysis was used to

1 determine the proportion of missing data for each case in the data set at each timepoint and to
2 establish if any missing data patterns existing. Cases considered to have large amounts of
3 missing data ($> 10\%$) were removed from the data set (cf. Hair et al., 2010). Cases with $<$
4 10% of missing data at each timepoint were retained with missing values either subsumed
5 within the subsequently computation of subscales or, for the subjective performance single
6 item, accounted for using the robust maximum likelihood estimation in MPlus. Item-level
7 data were then averaged to create parceled subscale scores for autonomy satisfaction,
8 competence satisfaction, relatedness satisfaction, subjective vitality, and positive affect. The
9 composite subscale scores were used to test for multivariate outliers using Mahalanobis
10 distances with $p < .001$ (Tabachnick & Fidell, 2013).

11 Following data screening, preliminary analyses were conducted to ascertain whether
12 age, gender, or competition level explained variance in the endogenous variables (i.e., basic
13 psychological need satisfaction [BPNS] and thriving [THRIVE]) at each timepoint (i.e., T1,
14 T2, or T3). For these analyses, average scores were computed for BPNS and THRIVE based
15 on the subscale indicators (i.e., autonomy satisfaction, competence satisfaction, and
16 relatedness satisfaction for BPNS; standardized values for subjective performance, subjective
17 vitality, and positive affect for THRIVE). Correlations were used to determine the
18 relationship with age, and ANOVAs¹ were used to establish whether any significant
19 differences existed on BPNS or THRIVE for gender and competition level. Given that some
20 participants were nested within teams, preliminary analyses were also conducted to determine
21 whether clustering effects existed. To gauge the potential impact from nesting, subscale-level
22 intraclass correlation (ICC) values were computed. Disagreement exists on the level at which
23 ICC values become noteworthy, with Muthén (1997) suggesting that when group sizes

¹ The distribution of participants across groups resulted in low covariance coverage and prevented the creation of group-based models using the GROUPING function in Mplus. As such, these analyses were conducted using ANOVAs in SPSS.

1 exceed 15 and findings yield ICC values of ≥ 0.10 , the multilevel structure of data should be
2 used; but others (e.g., Julian, 2001) arguing that ICC values < 0.10 should not be ignored.
3 Within these studies, variable effects have been found dependent on group size and group-to-
4 member ratio, and it is therefore important that any ICC values are interpreted against the
5 composition of the groups within the data set.

6 **Measurement model and longitudinal measurement invariance.** To calculate the
7 descriptive statistics for, and correlations between, basic psychological need satisfaction and
8 thriving, a measurement model was constructed using a configural longitudinal structure (see
9 Electronic Supplementary Resources); that is, the model was constructed without any
10 invariance constraints imposed over time (see, Marsh et al., 2016). Within the model, error
11 covariances between matching indicators (e.g., subjective performance) across assessments
12 were estimated freely because the same items were used and the sources of error were
13 anticipated to be the same (Geiser, 2012). Several indices were used to assess the fit of the
14 model to the data, including an absolute fit index (i.e., Standardized Root Mean square
15 Residual, SRMR), incremental fit indices (i.e., Comparative Fit Index, CFI; Tucker-Lewis
16 Index, TLI), and a parsimony correction index (i.e., Root Mean Square Error of
17 Approximation, RMSEA). Much debate exists on the appropriate thresholds for evaluating
18 goodness of fit on these indices (Gunnell et al., 2016), with longitudinal models commonly
19 acknowledged to display poor fit against conventional criteria (Preacher, 2010; Preacher et
20 al., 2008). As a result, acceptable values for models in the present study were considered to
21 be *close to* or above .90 for CFI and TLI, and *close to* or below .08 for RMSEA (Little,
22 2013). With regards to SRMR, Little (2013) notes that guidelines for acceptable values are
23 generally the same as for interpreting RMSEA (i.e., *close to* or below .08), but that “SRMR
24 has not been well evaluated for longitudinal models in any systematic way” (p. 112). Thus,
25 SRMR values were interpreted with caution in the present study.

1 The configural longitudinal structure was then used as a framework and baseline for
2 testing longitudinal measurement invariance. Longitudinal measurement invariance is used to
3 establish whether a construct is measured in the same metric across multiple occasions and is
4 achieved when any changes in the observable variables are carried by changes in the factor
5 scores (see, Grimm & Ram, 2009). In the present study, it was necessary to achieve scalar (or
6 strong) invariance (i.e., invariance in factor loadings and item intercepts over time), as the
7 purpose of the study was to compare latent means at different timepoints (see, Marsh et al.,
8 2016). Invariance testing followed a nested approach whereby increasingly restrictive models
9 were fitted to the data (Marsh et al., 2016). In the first step, the configural model was applied
10 to the data with all parameters freely estimated. In the second model, a metric configuration
11 was used with factor loadings held constant across assessments, and in the third model (i.e.,
12 the scalar configuration), factor loadings and intercepts were fixed to equality. CFI and
13 RMSEA indices were used to determine measurement invariance. Invariance was indicated
14 when changes of ≤ 0.010 were found for CFI (Cheung & Rensvold, 2002), and ≤ 0.015 for
15 RMSEA (Chen, 2007) when comparing each pair of models (e.g., configural and metric).

16 **Longitudinal structural equation model.** To address our research questions (RQ1-
17 3), a longitudinal structural equation model was constructed containing freely estimated
18 autoregressive (i.e., prediction from previous measurement of the same variable), situation-
19 specific (i.e., prediction from a variable measured at the same occasion), and cross-lagged
20 (i.e., prediction from temporally preceding variables) paths (see Figure 1). To answer RQ1,
21 first-order (e.g., THRIVE_T1 \rightarrow THRIVE_T2) and second-order (i.e., between nonadjacent
22 timepoints; e.g., THRIVE_T1 \rightarrow THRIVE_T3) autoregressive paths were specified to
23 examine whether previous levels of thriving predicted subsequent thriving. To answer RQ2,
24 THRIVE variables were regressed on BPNS variables measured at the same timepoint (e.g.,
25 BPNS_T2 \rightarrow THRIVE_T2) to measure situation-specific effects. To answer RQ3, first-order

1 (e.g., BPNS_T1 → THRIVE_T2) and second-order (e.g., BPNS_T1 → THRIVE_T3) cross-
2 lagged paths were included to examine the direct effects of BPNS on future thriving. Indirect
3 effects on THRIVE_T2 and THRIVE_T3 were also estimated to identify alternative
4 pathways through which prior perceived levels of basic psychological need satisfaction or
5 thriving influenced subsequent thriving. Lastly, to examine the consistency within these
6 relationships and potential stationarity in the model (i.e., the extent to which parameter
7 estimates are invariant over time), an alternative model was specified with the related
8 autoregressive, situation-specific, and first-order cross-lagged paths constrained to be equal.
9 Given the nested nature of the freely estimated (Model 1) and constrained (Model 2) models,
10 model fit was compared via Δ CFI and Δ RMSEA with the more parsimonious model
11 retained if the decrease in fit was < 0.01 for CFI and RMSEA increased by < 0.015 (Cheung
12 & Rensvold, 2002; Chen, 2007). The direct and indirect effects in the best fitting model were
13 interpreted using the unstandardized and standardized factor loadings, and statistical
14 significance ($p < .05$ and confidence intervals that did not cross zero). The statistical
15 significance of the indirect effects was also interpreted using bootstrap bias-corrected 95%
16 confidence intervals from 10,000 bootstrap replacement samples (MacKinnon et al., 2004).
17 To test the plausibility of the effect sizes for the direct paths derived from our design and
18 analytical approach, we conducted post hoc power analysis using Monte Carlo studies against
19 the threshold for desired power of 0.80 (Muthén & Asparouhov, 2002; Muthén & Muthén,
20 2015).

21 **Results**

22 **Data Screening and Preliminary Analysis**

23 Following data screening, 41 cases were removed from the data set for having more
24 than 35 days between responses, three cases were removed for missing $> 10\%$ of data at a

1 timepoint², and 11 multivariate outliers were excluded. Therefore, the sample size for the
2 remaining analyses was 213. The average time between the first, second, and third data
3 collection points were 21.32 days ($SD = 7.18$) and 22.03 days ($SD = 8.11$), respectively.
4 Preliminary analyses showed that age was not significantly associated with BPNS or
5 THRIVE at any time point ($ps > .41$), and that no significant differences were found based on
6 gender ($ps > .11$) or competition level ($ps > .08$). With regards to potential clustering effects,
7 the present study had a high group-to-member ratio (37:1) with 88 groups and an average
8 group size of 2.4 members. As such, although many ICC values were above the threshold of
9 0.10 proposed by Muthén (1997), the composition of groups in the data set meant a multi-
10 level framework was not deemed appropriate for subsequent analyses.

11 **Measurement Model and Longitudinal Measurement Invariance**

12 Descriptive statistics including the means and standard deviations for, and
13 correlations between, basic psychological need satisfaction and thriving were calculated from
14 the measurement model and are shown in Table 1. The measurement model demonstrated
15 good fit to the data ($\chi^2(102) = 149.722, p = .002$; CFI = .965; TLI = .948; SRMR = .068;
16 RMSEA [90% CI] = .047 [.030, .062]), and the correlations between the latent constructs
17 showed that all variables were related at each timepoint and over time (see Electronic
18 Supplementary Resources). This configural longitudinal factor model was then used as a
19 framework and baseline to test measurement invariance. As shown in Table 2, metric
20 invariance was achieved when the factor loadings were fixed over time ($\Delta CFI = .001$,
21 $\Delta RMSEA = .003$); however, scalar invariance was not initially found ($\Delta CFI = .023$,
22 $\Delta RMSEA = .012$). Interpretation of the modification indices suggested that releasing the
23 constraint on the intercept of T1 positive affect would achieve partial scalar invariance, which

² Missing value analysis suggested that the three cases followed a common pattern of failing to complete part or all of the items on the final questionnaire page, which resulted in the large quantity of missing data. Comparison of the descriptive data for the three cases to the remaining data set revealed no differences, suggesting that these cases may have represented a random subset of the population.

1 was considered to be the only solution available (Bengt Muthén, personal communication,
2 March 08, 2018). When this intercept was freely estimated, partial scalar invariance was
3 achieved ($\Delta\text{CFI} = .008$, $\Delta\text{RMSEA} = .004$).

4 **Longitudinal Structural Equation Model**

5 The two longitudinal structural equation models were constructed using the partial
6 scalar invariance framework to compare the fit of the freely estimated (Model 1) and
7 constrained (Model 2) models to the data. Model 1 showed acceptable fit for the data ($\chi^2(120)$
8 $= 180.248$, $p < .001$; CFI = .956; TLI = .944; SRMR = .083; RMSEA [90% CI] = .049 [.033,
9 .063]). When compared to the fit of Model 2 ($\chi^2(125) = 181.716$, $p < .001$; CFI = .959; TLI =
10 .949; SRMR = .085; RMSEA [90% CI] = .046 [.030, .060]), the changes in CFI and RMSEA
11 did not indicate notable reductions in model fit when imposing the additional constraints.
12 This comparison therefore favored the more parsimonious Model 2 and indicated that
13 stationarity existed in the model. The standardized factor loadings and statistical significance
14 for the direct autoregressive, situation-specific, and cross-lagged paths for Model 2 are
15 displayed in Figure 2; estimated power for each path can be viewed in Table 3. The paths
16 show that first-order autoregressive paths exist for BPNS and for THRIVE, and that second-
17 order autoregressive effects also exist for THRIVE (RQ1). Situation-specific effects were
18 found with BPNS shown to be a consistent, significant predictor of THRIVE over time
19 (RQ2). First-order and second-order cross-lagged paths between BPNS and THRIVE were
20 not found to be positive and statistically significant (RQ3). However, previous experience of
21 BPNS was found to have positive and statistically significant indirect effects on subsequent
22 THRIVE (RQ3). Specifically, the (standardized) indirect effect of BPNS_T1 on THRIVE_T2
23 was 0.678 ($p < .001$) resulting from paths via BPNS_T2 (0.486, $p < .001$) and THRIVE_T1
24 (0.192, $p = .01$). BPNS_T1 was also found to have a positive and significant indirect effect
25 on THRIVE_T3 (0.498, $p < .001$) resulting from paths via THRIVE_T1 (0.219, $p = .004$), the

1 BPNS first-order autoregressive path (0.292, $p = .001$), BPNS_T2 and THRIVE_T2 (0.115, p
2 = .02), and THRIVE_T1 and THRIVE_T2 (0.045, $p = .017$). BPNS_T2 had a positive and
3 significant indirect effect on THRIVE_T3 (0.610, $p < .001$) resulting from the paths via
4 BPNS_T3 (0.437, $p = 0.001$) and THRIVE_T2 (0.173, $p = .016$). In contrast, while a positive
5 and significant direct path existed between THRIVE_T1 on THRIVE_T3, the total indirect
6 path for THRIVE_T1 via THRIVE_T2 was non-significant (0.066, $p = .215$). These effects
7 were verified using the bias-corrected bootstrap 95% confidence intervals; these results,
8 along with the full results from Model 2, are available in the Electronic Supplementary
9 Resources.

10 Discussion

11 The aim of this study was to conduct the first longitudinal examination of thriving in
12 sport and, in so doing, provide novel insight into the enduring effect of thriving and the role
13 played by basic psychological need satisfaction. The results from the longitudinal structural
14 equation model showed thriving to be highly predicted by both the experience of recent
15 thriving and the satisfaction of the basic psychological needs for autonomy, competence, and
16 relatedness. More specifically, and in response to RQ1, experiencing thriving was found to
17 positively predict future thriving in sporting encounters up to 28 days after its occurrence.
18 With regards to RQ2, stationarity was found within the model, suggesting that basic
19 psychological need satisfaction had a consistent, facilitative effect on thriving when measured
20 on repeated occasions. Furthermore, and in addressing RQ3, significant indirect effects were
21 found for predicting thriving from the experience of basic psychological need satisfaction in a
22 previous encounter; yet no direct effects were observed. Additionally, and in-keeping with
23 the tenet that the basic psychological needs are universal and invariant across groups (Ryan &
24 Deci, 2017), no effects were found based on age, gender, or competitive level suggesting that
25 the findings are consistent across these groups. The findings from the main analyses are

1 discussed in turn, in the following paragraphs.

2 With growing interest in the experience of thriving in sport, scholars have begun to
3 speculate on the lasting effect of thriving for future functioning with both positive and
4 negative outcomes proposed (see, Brown et al., 2018). The results of the present study
5 provide original and robust evidence for a positive predictive effect, with statistically
6 significant direct paths found between thriving levels measured on adjacent (e.g., timepoint
7 one and timepoint two) and nonadjacent (i.e., timepoint one and timepoint three) timepoints.
8 The fortnightly spacing between measurements allowed for experiences in sequential
9 encounters to be collected, supporting the notion that the experience of thriving in one
10 encounter (e.g., match, competition) may act as an enabler or springboard for thriving in the
11 next (Brown et al., 2018). Beyond these neighboring encounters, it is also particularly
12 interesting to note that levels of thriving reported over the preceding month (as measured at
13 timepoint one) had a predictive effect on levels of thriving up to 28 days after that
14 measurement (i.e., at timepoint three). Curiously, this effect occurred directly, rather than via
15 an intermediary experience of thriving, suggesting that this effect occurred independent of the
16 second encounter and any transient changes that it may have had. A possible explanation for
17 this finding may reside in the level of generality used at timepoint one (i.e., aggregated
18 experiences over the past month), as this may have captured a broader, enduring experience
19 of thriving (see, e.g., Brown, Arnold, Fletcher, et al., 2017) which provided a more
20 substantive effect than an experience in a specific, one-off encounter. Indeed, tentative
21 support for this interpretation is offered by the greater magnitude of predictive effects found
22 from thriving at timepoint one compared to thriving at timepoint two. This interpretation
23 does, however, rely on the assumption that participants experienced stable levels of
24 functioning across sporting encounters over the month when, in reality, they may have
25 perceived an overall, general experience of thriving, but subsumed within that perception

1 were a mixture of thriving and non-thriving experiences. To test this assumption in future
2 work, researchers are encouraged to utilize multilevel or latent growth curve modeling
3 frameworks to examine the within-person changes in thriving over time (see, Stenling,
4 Ivarsson & Lindwall, 2017). Returning to the present findings, these results afford athletes,
5 coaches, and practitioners the knowledge that if they can successfully create social contexts
6 that promote thriving on one occasion (see, Brown et al., 2021), then it can have lasting
7 effects on future thriving.

8 The second research question sought to better understand the relationship between
9 basic psychological need satisfaction and thriving and, specifically, whether the predictive
10 relationship previously identified within the literature (see, Brown, Arnold, Standage, et al.,
11 2017; Brown, Arnold, et al., 2020; see also, Ryan & Deci, 2017) was replicated over time.
12 Commensurate with existing work, a positive, predictive effect was repeatedly found between
13 the extent to which performers experienced satisfaction of autonomy, competence, and
14 relatedness and their reported levels of thriving. Furthermore, stationarity was supported
15 within the model suggesting that this predictive effect was consistent over time. Although
16 stationarity effects have not previously been examined in relation to thriving, research has
17 considered the temporal and longitudinal associations of basic psychological need satisfaction
18 with subjective vitality, positive affect, and performance separately. For example, and via a
19 four-week diary study, Gagné et al. (2003) demonstrated that increases in basic psychological
20 need satisfaction experienced during a training season predicted pre- to post-practice levels of
21 subjective vitality and positive affect. Similarly, Cheval et al. (2017) showed that within-
22 person variations in autonomy and competence satisfaction were associated with within-
23 person changes in subjective vitality, and Verner-Filion and Vallerand (2018) found that
24 satisfaction of each of the three needs was positively associated with within-person changes
25 in positive affect over time. To date, no studies have considered the association of basic

1 psychological need satisfaction with subjective performance over time; however, where
2 studies do exist for alternative performance measures (e.g., Sheldon et al., 2013; Verner-
3 Filion & Vallerand, 2018), no direct associations have been found between players'
4 fluctuating levels of psychological need satisfaction and objective performance (e.g.,
5 basketball shot percentage, coach assessed performance). Notwithstanding the lack of direct
6 effects, it is interesting to note that Verner-Filion, and Vallerand (2018) did find indirect
7 effects for within-person changes in competence satisfaction on within-personal changes in
8 performance via concurrent changes in the quality of preparation. Taken collectively, these
9 replicated findings position basic psychological need satisfaction as a reliable and highly
10 important precursor to indices of thriving; thereby offering coaches and practitioners a
11 systematic framework through which they can positively impact the occurrence of thriving in
12 the athletes they work with. To this end, being able to map the qualities and nature of the
13 inputs and environments that are supportive of autonomy, competence, and relatedness holds
14 particular importance to sport practitioners (cf. Standage & Ryan, 2020).

15 As an adjunct to the second research question, in research question three we also
16 addressed whether experiencing basic psychological need satisfaction in a prior sporting
17 encounter had a predictive effect of future levels of thriving. In agreement with previous
18 literature (see, e.g., Balaguer et al., 2012, 2018), significant positive associations were found
19 between levels of basic psychological need satisfaction reported at one timepoint and levels
20 of thriving experienced in subsequent encounters (see Table 1). However, when examining
21 the direct predictive effects via the cross-lagged paths between adjacent and nonadjacent
22 timepoints, no significant effects were found and the direction of the relationship between
23 prior need satisfaction and subsequent thriving shifted from a positive correlation to a
24 negative regression path. These results may be indicative of a suppressor situation (cf. Cohen
25 & Cohen, 1975) and infer a scenario where the suppressor variable (in this instance,

1 BPNS_T1 or BPNS_T2) correlates with the dependent variable (i.e., THRIVE_T2 or
2 THRIVE_T3) and shares some relevant information in common with it, but that this level of
3 shared relevant information is exceeded by the level of (dependent variable) irrelevant
4 information shared between the suppressor variable and the other explanatory variables (see,
5 for a description of negative suppression, Maassen & Bakker, 2001). The interpretation of
6 this finding is that prior need satisfaction does not directly predict future thriving when
7 modeled alongside prior levels of thriving (i.e., existence of autoregressive effects) and
8 situation-specific variables (i.e., need satisfaction measured at the same timepoint as
9 thriving); however, it does not mean that need satisfaction has a negative effect on future
10 thriving or that it should be discarded if examined in isolation to the other variables. Indeed,
11 significant indirect effects were found for levels of basic psychological need satisfaction over
12 the past month (as measured at timepoint one) and in a specific, previous encounter (as
13 measured at timepoint two) on future thriving, suggesting that general or one-off experiences
14 can have an indirect effect on future match experiences. Thus, while the present findings do
15 not demonstrate a direct effect, they do provide novel evidence that establishing a sports
16 environment wherein athletes perceive their psychological needs to be satisfied will not only
17 have a positive effect on their future motivational experiences, but it will also likely have
18 subsequent enhancing effects on thriving up to 28 days later.

19 Notwithstanding these original findings, it is prudent to identify the study limitations
20 and areas for future research. First, it should be noted that some participants' level of
21 sporting representation altered during the study as individuals moved between teams (e.g.,
22 junior to senior; club to regional), but that it was not possible to conduct analysis on such
23 changes as a result of their idiosyncratic nature. As participants were required to provide
24 subjective judgments of performance and well-being, it was anticipated that they would alter
25 their expectations at each given competitive level and thus offer equitable assessments of

1 thriving. That said, it may be of interest for future researchers to investigate whether thriving
2 at one competitive level, can facilitate subsequent thriving at a higher or lower level. Second,
3 given the multi-sport sample recruited in the present study, and the variability inherent in
4 assessing the outcome of a match/competition across different sports (e.g., win-draw-loss in
5 netball vs. ranking in swimming) and in interpreting the significance of the outcome (e.g., the
6 size of worthwhile effects; Standage, 2012), we did not deem it appropriate to include
7 information pertaining to match outcome in our analyses. However, we acknowledge that this
8 may present as a limitation of our study as match/competition outcome as well as perceived
9 success (McAuley & Tammen, 1989) may have provided a source of variance in need
10 satisfaction and thriving, particularly with the participants completing their measures after
11 their self-nominated sporting encounter. Third, by centering the analyses on the factors
12 considered most proximal to the occurrence of thriving (i.e., previous levels of thriving, basic
13 psychological need satisfaction), this study has not examined the social and environmental
14 factors that may enable this process (e.g., psychologically safe environment, social support,
15 coach need supportive behaviors). Although a large body of research exists on how
16 autonomy, competence, and relatedness can be promoted in sport settings (see, for a review,
17 Standage & Ryan, 2020), further examining the context in which performers are operating in
18 future work would provide a more complete account of the thriving process.

19 Fourth, the test of longitudinal measurement invariance returned only partial-scalar
20 invariance with the intercept of T1 positive affect needing to be freely estimated. It is
21 possible that this resulted from measurement error occurring because of the different
22 instructional sets used between the first and subsequent timepoints with participants asked to
23 reflect on a more global level of generality at timepoint one compared to timepoints two and
24 three. Fifth, this study used a variable-based approach to analyze the predictive effects within
25 the sample. This approach is limited in so much as it means we were not able to partial out

1 within-person processes from between-person differences, potentially resulting in erroneous
2 conclusions about the lagged parameters if either basic psychological need satisfaction or
3 thriving exhibited trait-like, time-invariant characteristics (see, Hamaker et al., 2015).
4 Although we attempted to test for these effects using a random-intercepts cross-lagged panel
5 model (Hamaker et al., 2015; Hamaker, 2018a, b), this model failed to converge; therefore,
6 the results from this analysis are not reported. Lastly, post hoc power calculations suggest
7 that the analyses may have lacked statistical power for the autoregressive and cross-lagged
8 paths based on the sample size, study design, and analytical approach, which may have
9 resulted in null hypotheses being incorrectly accepted for some parameters. To inform sample
10 size calculations and improve power in future studies, researchers are encouraged to draw on
11 the parameter estimates and missing data patterns found herein, along with those from the
12 emerging literature on thriving in sport (e.g., Brown, Arnold, Standage, et al., 2017; Brown,
13 Arnold, et al., 2020).

14 To conclude, this study represents the first longitudinal examination of thriving in
15 sport. In so doing, it provides original insight into the positive, predictive effects of previous
16 levels of thriving on subsequent thriving experiences, and of the consistent role played by
17 basic psychological need satisfaction on the occurrence of thriving over time. These findings
18 highlight basic psychological needs as an important means through which coaches and
19 practitioners can initiate thriving in the athletes they work with and, uniquely, how this
20 experience can be sustained across a series of sporting encounters (e.g., run of fixtures,
21 rounds within a competition).

22 Electronic Supplementary Resources

23 Electronic supplementary resources can be accessed here:

24 https://osf.io/h6uvj/?view_only=0b88f478ef544b3ba55fb5a781867875

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1 Table 1

2 *Descriptive Statistics and Correlations Between Basic Psychological Need Satisfaction and Thriving*

	1	2	3	4	5	6
1. BPNS_T1	—					
2. BPNS_T2	.68***	—				
3. BPNS_T3	.37**	.50***	—			
4. THRIVE_T1	.66***	.47***	.31***	—		
5. THRIVE_T2	.52***	.75***	.56***	.49***	—	
6. THRIVE_T3	.39***	.41***	.79***	.50***	.60***	—
Mean	5.86	5.85	5.78	6.61	6.88	6.41
S.D.	0.57	0.57	0.70	1.08	1.15	1.30

3 *Note.* Values computed from measurement model. Mean, standard deviation, and correlation values are model estimates. BPNS = basic
 4 psychological need satisfaction; THRIVE = thriving.

5 ** $p < .01$. *** $p < .001$.

6

1 Table 2

2 *Results of the Longitudinal Measurement Invariance Tests*

Model	<i>N</i>	$\chi^2_{(df)}$	TLI	CFI	Δ CFI	RMSEA	Δ RMSEA	RMSEA 90%CI
Configural	213	149.722** ₍₁₀₂₎	0.948	0.965	—	0.047	—	[0.030, 0.062]
Metric	213	156.100** ₍₁₁₀₎	0.953	0.966	0.001	0.044	0.003	[0.027, 0.060]
Scalar	213	196.372*** ₍₁₁₈₎	0.926	0.943	0.023	0.056	0.012	[0.042, 0.069]
Partial-scalar	213	174.957*** ₍₁₁₇₎	0.945	0.958	0.008	0.048	0.004	[0.033, 0.063]

3 *Note.* Configural (all parameters freely estimated); Metric (factor loadings constrained to equality); Scalar (factor loadings and intercepts
4 constrained to equality); Partial-scalar (factor loadings and intercepts constrained to equality, but with one intercept freely estimated); $\chi^2_{(df)} = \chi$ -
5 square and degrees of freedom; TLI = Tucker-Lewis Index; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of
6 Approximation; CI = confidence interval.
7 ** $p < .01$ *** $p < 0.001$

1 Table 3

2 *Post Hoc Power Results*

Path	Power (% Sig Coeff)
TH1 → TH2	0.576
TH2 → TH3	0.224
TH1 → TH3	0.518
NS1 → TH1	1.000
NS2 → TH2	1.000
NS3 → TH3	1.000
NS1 → TH2	0.226
NS2 → TH3	0.134
NS1 → TH3	0.066
NS1 → NS2	1.000
NS2 → NS3	0.998
NS1 → NS3	0.066

3 *Note.* Sample size = 213, with the proportion of missing data set at 47% for timepoint 3 to
 4 reflect approximate attrition in responses. Power calculated using parameter values from
 5 Model 2 taken to represent population values.

Figure Captions

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Figure 1. Longitudinal structural equation model displaying the autoregressive paths between repeated measures of the same variable, situation-specific paths between basic psychological need satisfaction (BPNS) and thriving (THRIVE) on the three occasions (T1, T2, and T3), and the cross-lagged paths between temporally preceding variables. In addition to these direct paths, an illustrative indirect path is depicted by the letters *a* and *b*.

Figure 2. Model 2 (Stationarity). BPNS = basic psychological need satisfaction, THRIVE = thriving. All direct path coefficients are standardized. ** $p < .01$, *** $p < .001$.