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Research article

Determining Dimensionality of Exercise Readiness Using Exploratory Factor Analysis

Kelley Strohacker ✉ and Rebecca A. Zakrajsek
Department of Kinesiology, Recreation, and Sport Studies, Applied Exercise Physiology Laboratory, University of Tennessee, Knoxville, USA

Abstract
Assessment of "exercise readiness" is a central component to the flexible non-linear periodization (FNLP) method of organizing training workloads, but the underlying factor structure of this construct has not been empirically determined. The purpose of this study was to assess construct dimensionality of exercise readiness using exploratory factor analysis. The result of which serve as initial steps of developing a brief measure of exercise readiness. Participants consisted of students recruited from undergraduate Kinesiology courses at a racially diverse, southern University. Independent, anonymous online survey data were collected across three stages: 1) generation of item pool (n = 290), 2) assessment of face validity and refinement of item pool (n = 168), and 3) exploratory factor analysis (n = 684). A principal axis factor analysis was conducted with 41 items using oblique rotation (promax). Four statistically significant factors, as determined through parallel analysis, explained 61.5% of the variance in exercise readiness. Factor 1 contained items that represented vitality (e.g., lively, revived). Factor 2 items related to physical fatigue (e.g. tired, drained). Factors 3 and 4 were descriptive of, discomfort (e.g. pain, sick) and health (i.e. healthy, fit), respectively. This inductive approach indicates that exercise readiness is comprised of four dimensions: vitality, physical fatigue, discomfort, and health. This finding supports readiness assessment techniques currently recommended for practitioners according to the FNLP model. These results serve as a theoretical foundation upon which to further develop and refine a brief survey instrument to measure exercise readiness.

Key words: Flexible nonlinear periodization, vitality, physical fatigue, discomfort, health.

Introduction

Adults in the United States (U.S.) are encouraged to accumulate at least 150 minutes of moderate intensity aerobic exercise, 75 minutes of vigorous intensity aerobic exercise, or a combination of the two each week (ACSM, 2014; USDHHS, 2008). Despite the known benefits of regular exercise (Pate et al., 1995; Thompson et al., 2003; Wing, 1999) only 62% of adults surveyed subjectively reported meeting the aerobic physical activity guidelines (Tucker et al., 2011). When measured objectively, less than 10% of adults meet recommendations (Troiano et al., 2008; Tucker et al., 2011). In 1982, Dishman surmised that, in order to improve long-term behavior, it is likely necessary to compromise between exercise doses that are physiologically ideal and those that are behaviorally manageable. To achieve this goal, Ekkekakis (2011) advocated that exercise prescriptions be designed based on a tripartite model, which states that, in addition to maximizing physiological outcomes and minimizing risk, exercise should also be prescribed such that negative psychological responses are reduced. One potential approach of minimizing negative psychological outcomes is to prescribe exercise bouts in response to how an individual feels on a given day, rather than impose uniform workloads regardless of pre-exercise state.

Flexible non-linear periodization (FNLP) (Kraemer and Fleck, 2007) is a relatively new model of training organization, wherein daily exercise workloads are assigned in response to an individual's "readiness" to train or to exercise. In the context of FNLP, exercise readiness refers to physical and/or mental states of readiness and are quantitatively measured by the conditioning specialist or perceptually gauged by the trainee. Level of readiness is used to assign daily exercise workloads, such that low-demand workloads are applied in response to low readiness and high-demand workloads are applied in response to high readiness. Prior to the development of FNLP, Martin and colleagues (1984) conducted a series of experiments within a twice-per-week walking/jogging course for inactive adults and demonstrated that flexible goal setting (i.e., modification of daily distance goal based on how each individual felt each day) improved attendance rates and self-reported exercise level at follow up, compared to participants receiving fixed distance goals imposed by instructors. Although these findings support the idea of flexible aerobic training on a day-to-day basis, no information was provided regarding what specific feelings were measured and how they were assessed. Given that assessing exercise readiness is a key factor in implementing FNLP-based exercise prescriptions and that such prescriptions may be more behaviorally manageable, it is important to use a valid and reliable tool in order to measure and base training decisions upon this construct. The present paper outlines the initial steps (i.e., phase one) in developing a brief measure of exercise readiness, which include surveying individuals to identify items relevant to perceived readiness to exercise and conducting exploratory analyses procedures to determine dimensionality of this construct.

Limitations with current approaches in assessing exercise readiness

Kraemer and Fleck (2007) suggested a six-step checklist to determine readiness to train within the context of FLNP: 1) interactions with the trainee, 2) injury status, 3) hydration status, 4) mental/physical fatigue ratings, 5)

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performance of a physical task (e.g. vertical jump), and 6) initial performance of training workload. Taken together, assessment of these six steps purportedly yields insight into the psychological and physical readiness of the trainee. This approach is likely based upon a series of observations and practices in regards to athletes or other highly trained individuals, but is not, to our knowledge, explicitly supported by an empirically driven conceptualization of exercise readiness. Further, this approach relies on collecting readiness information over a series of observations, physical tasks, and surveys that, while thorough, may be impractical to implement in full within intervention settings targeting untrained adults. For example, the full six-step process may be too time consuming with a relatively large participant-to-staff ratio and there may be additional limitations in regards to necessary equipment (e.g., hydration or performance testing) depending on the type and setting of the intervention.

Currently there are two published studies that have implemented FNLP and used a condensed approach to the above checklist when assessing exercise readiness. In an initial study, McNamara and Stearne (2010) compared the effects of two equivalent strength training programs organized using either non-linear periodization or FLNP. Participants in both conditions completed either a 10-, 15-, or 20-repetition maximum workout each day. Individuals in the non-linear group were assigned which workout to complete whereas those in the FNLP group were free to choose which workout to complete each day based on their estimated pre-exercise energy levels on a scale from 0 (no energy) to 10 (fully motivated with maximum energy). Two concerns with this approach are that 1) the authors did not provide explicit rationale for the use of a simple energy scale, and 2) the low anchor relates only to energy level while high anchor relates to both motivation and energy, potentially reducing the construct validity of the measure. None-the-less, this approach most closely represents the fourth step (mental/physical fatigue ratings) on Kraemer and Fleck's checklist. Both groups improved equally on chest press and standing long-jump performance with the FNLP group resulting in significantly greater gains in leg strength compared to the non-linear group. In a later study, McNamara and Stearne (2013) compared the effects of FNLP strength/endurance (i.e. concurrent) training with and without the addition of maximal effort cycling. In this intervention, participants were allowed to adjust workout intensity based on their current mood, preference, and the aforementioned 1-10 energy level scale. Although maximal effort cycling did not provide additional benefits, results indicated that a flexible non-linear concurrent training program improved strength/power in healthy individuals. Unfortunately, descriptions of preference and mood measures utilized were not provided. Still, these studies do lend initial support that gauging exercise readiness is an area of interest to practitioners, especially if it can be done with a rather brief and practical approach and that using such methods to implement FNLP results in positive fitness outcomes.

The notion of assessing readiness to exercise, or variants thereof, has also emerged in research studies that were not specifically designed with the FNLP framework in mind. In the earliest of these studies researchers aimed to determine whether ingesting an energy drink prior to exercise impacted exercise readiness and performance (Duncan et al., 2012). Prior to exercise testing, participants completed separate 0-10 visual analog scales to assess readiness to invest mental and physical effort, with higher scores indicating higher readiness. Results indicated that ingesting the energy drink increased readiness to invest mental effort, reduced ratings of perceived exertion, and promoted a greater number of repetitions to failure compared to the placebo group. In 2014 researchers utilized the Perceived Readiness Scale throughout high intensity interval training bouts to assess readiness to recommence exercise following rest intervals by having participants indicate their score on a scale of 1-7 (1 = fully recovered and able to exercise at maximal intensity, 4 = adequately recovered and able to exercise at the required intensity, 7 = exhausted and unable to exercise) (Laurent et al., 2014). Developed by Edwards et al. (2011), using the Perceived Readiness Scale to gauge recovery between high intensity intervals was found to be as accurate as measuring heart rate for recovery in regards of yielding adequate performance. However, the Perceived Readiness Scale would not be appropriate for pre-exercise readiness assessments because the descriptors at each level gauge participants' perception of recovery following a previous bout of activity, which may not be relevant outside of interval or circuit training. Furthermore, perception of recovery may not be synonymous with exercise readiness.

Although using a single item "energy" or "recovery" measure of exercise readiness may have some face validity, the underlying factor structure of exercise readiness has not been explored or defined. Given the multifactorial nature of exercise behavior, it is imperative that a more thorough approach be applied in order to understand the theoretical basis of exercise readiness as a construct. Understanding latent variables underlying the construct of exercise readiness would also help inform survey design to create a valid and reliable brief measure of exercise readiness. Thus, the purpose of the current study was to empirically identify latent variables underlying the construct of exercise readiness using exploratory factor analysis. This objective was met across three stages: 1) generation of a pool of items related to exercise readiness 2) assessment of face validity and refinement of item pool, and 3) exploratory factor analysis of refined items. An inductive, exploratory approach was used in conducting the factor analysis given the lack of previous empirical exploration of this construct and no clear delineation of potential exercise readiness factors.

Methods

Experimental approach to the problem

The methods for our study involved three stages. The objective of Stage 1 was to create a pool of appropriate items that would be subjected to the exploratory factor analysis procedures. First, individuals were invited to create their own list of words they felt would describe states of high or low readiness to exercise at any given time. Because there is little theoretical basis in defining the construct of exercise readiness and its factor structure, a relatively large sample of words was created for the item pool (Cattell, 1978). To accomplish this, items from previously validated psychometric surveys relevant to exercise behavior were added to the most frequently cited items that our participants generated. The objective of the Stage 2 was to examine participants' perceptions about how experiencing each item would alter readiness to exercise (i.e., assessment of face validity) and use this information to refine and trim items. The objective of Stage 3 was to conduct an exploratory factor analysis on retained items to determine distinct factors upon which items uniquely loaded.

Participants

The Institutional Review Board (IRB) approved the use of anonymous surveys to collect data across the three stages. Participants were informed about the purpose of the study for each stage, that participation was voluntary, and that completion of the anonymous survey served as consent to participate. University undergraduate students were chosen as a convenient sample for each stage. The surveys were disseminated within Kinesiology courses as these students likely have experience with exercise and could provide meaningful input regarding words related to high or low readiness to exercise. Distinct samples of participants from separate Kinesiology courses were recruited for each stage and no participant received compensation for participating in the study. Demographic data were not collected from participants (n = 290) during Stage 1. While this initial approach provided students with full anonymity, the lack of demographic data prohibits definite conclusions regarding general age, physical activity level, and gender/racial distributions of participants contributing to Stage 1. However, given that all recruitment took place within undergraduate kinesiology courses at the same University and the demographic characteristics were relatively similar between Stages 2 and 3, it is reasonable to speculate that the sample for Stage 1 did not substantially deviate from those assessed during later stages. Participant characteristics from Stage 2 (n = 168) and Stage 3 (n = 684) are summarized in Table 1.

Procedures

All surveys were conducted online. Students were initially invited to participate in the study using Blackboard announcements that provided an active link to the respective, anonymous surveys created through Qualtrics.

Stage 1

Participants in Stage 1 answered the following questions: 1) "How do you know if you are "ready to exercise" at any given time?", 2) "What are some words, adjectives, or phrases that describe how you might feel if you have a high level of readiness to exercise at a given time?", and 3) "What are some words, adjectives, or phrases that describe how you might feel if you have a low level of readiness to exercise at a given time?". Respondents could list up to 10 words for questions 2 and 3. The most frequently cited words were combined with items from surveys that assess relevant exercise-related constructs in order to finalize the initial item pool. These surveys included the vigor, fatigue, and tension subscales of the Profile of Mood States (POMS) (McNair, 2003), the positive well-being, psychological distress, and fatigue subscales of the Subjective Exercise Experiences Scale (SEES) (McAuley, 1994), the positive engagement, revitalization, tranquility, and physical exhaustion subscales of the Exercise Feelings Inventory (EFI) (Gauvin L., 1993), the positive affect and negative affect subscales of the Positive And Negative Affect Schedule (PANAS) (Watson D., 1988) and the anchors of the Feeling Scale (FS) (Hardy, 1989).

Stage 2

Participants in Stage 2 were instructed to think about the question "how ready are you to exercise right now" and indicate the extent to which each item (item pool generated during Stage 1) would decrease or increase their readiness to exercise using a 7-point, bipolar Likert scale (-3 = strongly decrease, -2 = moderately decrease, -1 = slightly decrease, 0 = no effect, 1 = slightly increase, 2 = moderately increase, 3 = strongly increase). Items were retained for subsequent factor analysis if 80% or more participants (e.g., 4 out of every 5 individuals) reported that it would either increase or decrease readiness to exercise. Regarding demographic characteristics, Participants were also asked to indicate their age, gender, racial group, and how many days per week they engaged in at least moderate-intensity exercise. For brevity in these initial phases, no additional questions were asked to determine exercise mode or duration per day, health, or injury status.

Stage 3

Participants recruited for Stage 3 were instructed to indicate the degree to which they were experiencing each of the retained items from Stage 2 "right now" using a 7-point Likert scale (0 = not at all, 3 = moderately, 6 = extremely). Additionally, participants were asked to

Table 1. Sociodemographic characteristics.

		Stage 2 (n = 168) Mean (SD) or %	Stage 3 (n =6 84) Mean (SD) or %
Age (years)		23 (3.5)	21.4 (4.6)
Days of Exercise Per Week		3.3 (1.7)	2.8 (1.9)
Women		54.0%	63.5%
Race	**Non-Hispanic White**	36.3%	22.2%
	Hispanic / Latino	23.2%	27.0%
	African American	14.9%	12.8%
	Asian/Pacific Islander	18.5%	31.5%
	Unlisted Racial Category	7.1%	6.5%

indicate age, gender, racial group, and exercise frequency.

Statistical analyses

All statistical procedures were conducted using SPSS v.21 software. Frequency analyses were conducted to determine the most common words reported in Stage 1. In Stage 2, the percentage of respondents indicating that an item would increase or decrease readiness to exercise was calculated by summing percentage values across the three positive (increasing readiness) or three negative (decreasing readiness) Likert scale categories. Items retained for Stage 3 were subjected to a principal axis factor analysis, with factor extraction limited based on the results of a parallel analysis to determine statistically significant factors. Given the tendency for correlation among psychological factors, an oblique (promax) rotation was applied in the analysis.

Results

Stage 1

In response to the second and third open-ended survey items, participants reported 1547 words describing a high level of readiness to exercise and 1590 words describing a low level of readiness to exercise. Participants listed an average of 5.3 (±2.60) high readiness words and 5.5 (±2.65) low readiness words. Frequency analyses indicated that 20 words accounted for 61.3% of the total number of high readiness items and 21 words accounted for 60.5% of the low readiness items. These 41 words are reported in Table 2.

Table 2. Common words associated with high and low exercise readiness.

High Readiness Words		Low Readiness Words	
Energetic	Active	Tired	Sick
Excited	Anxious	Lazy	Stressed
Motivated	Prepared	Sleepy	Sore
Pumped	Awake	Unmotivated	Lethargic
Determined	Confident	Depressed	Slow
Happy	Alert	Hungry	Low Energy
Hyped	Loose	Exhausted	Bored
Focused	Warmed Up	Sad	Fat
Strong	Inspired	Weak	No Time
Healthy	Fit	Too Busy	Full
		Sluggish	

One item, "prepared," was considered a synonym of the primary construct of readiness by the authors and was excluded. The resulting 40 participant-generated items were combined with 46 unique adjectives drawn from the scales and surveys listed in Table 3. Further, the responses to the first open-ended survey item, "How do you know if you are ready to exercise at any given time?," were evaluated and 17 additional items were identified that were deemed potentially relevant to the readiness construct (appropriately dressed, hydrated, frustrated, down, disinterested, pain, injured, stretched, unhealthy, uncomfortable, rested, drowsy, nourished, fueled, enough time, overscheduled, comfortable). In total, the final item pool contained 103 items.

Stage 2

From the pool of 103 items generated in Stage 1, a total of 41 items were reported by at least 80% of the participants in Stage 2 as either increasing or decreasing exercise readiness. Table 4 contains the 26 items that participants indicated would increase exercise readiness and to what degree on the Likert scale. Table 5 contains the 15 items that participants indicated would decrease exercise readiness and to what degree on the Likert scale.

Stage 3

Preliminary factor analysis: Data collected on the 41 items retained from Stage 2 were subjected to a principal axis factor analysis in Stage 3. The Kaiser-Meyer-Olkin (KMO) measure determined sampling adequacy to be superb (KMO = .97) (Field, 2005). Additionally, KMO values for individual items ranged between .77 and .98 (with 39 out of 41 items having KMO values >.90), well above the recommended value of .50 (Field, 2005). Bartlett's test of sphericity (chi square = 21039.87, $p < 0.001$) indicated that item correlations were sufficiently large for factor analysis (Field, 2005).

Factor extraction: The initial analysis identified six factors based on eigenvalues greater than 1.0. However, experts have indicated that determining factors based on eigenvalues greater than 1.0 tends to overestimate relevant factors (Zwick and Velicer, 1986). Analysis of the scree plot supported the inclusion of two to four factors, though the reliability of this technique is poor, even amongst experts (Zwick and Velicer, 1986). O'Connor (2000) suggested that more statistically sound techniques should be applied to exploratory factor analyses in order to most accurately determine the number of factors, particularly parallel analysis using a Monte Carlo simulation and Velicer's minimum average partial (MAP) test. For a thorough approach, it has also been suggested that researchers administer both tests because the procedures complement each other in that parallel analysis tends to err in the direction of overextraction and MAP tends to err in the direction of underextraction (O'Connor, 2000).

Table 3. Items added from existing questionnaires.

Questionnaire	Total items possible	Unique items added to the readiness item pool
Profile of Mood States (fatigue, vigor, tension subscales)	24	18 items - tense, shaky, on edge, panicky, relaxed, uneasy, restless, nervous, lively, cheerful, full of pep, carefree, vigorous, worn out, listless, fatigued, weary, bushed
Subjective Exercise Experiences Scale	12	8 items - great, positive, terrific, awful, crummy, discouraged, miserable, drained
Exercise Feelings Inventory	12	6 items - enthusiastic, upbeat, refreshed, revived, calm, peaceful
Positive and Negative Affect Schedule	20	12 items - interested, proud, attentive, distressed, upset, guilty, scared, hostile, irritable, ashamed, jittery, afraid
Feeling Scale anchors	2	2 items – good, bad

Table 4. Items perceived to increase exercise readiness.

Item	Percentage of Respondents Reporting			
	Slightly Increase	Moderately Increase	Strongly Increase	Overall Increase
Active	19.2	28.1	45.5	92.8
Motivated	15.7	29.5	45.8	91
Pumped	18	25.7	46.7	90.4
Energetic	19	32.1	38.7	89.9
Determined	18.7	27.7	42.8	89.2
Strong	25.9	27.1	36.1	89.1
Healthy	21.4	35.1	31	87.5
Happy	32.5	29.5	25.3	87.3
Refreshed	34.9	37.3	15.1	87.3
Fueled	23.5	31.9	31.3	86.7
Inspired	28.7	25.7	31.7	86.1
Hyped	20.1	29.9	36	86
Lively	38.3	28.1	19.2	85.6
Fit	13.9	28.9	42.8	85.6
Good	41.3	31.7	12.6	85.6
Positive	31.9	31.9	21.1	84.9
Upbeat	25.6	38.1	20.8	84.5
Great	30.1	27.1	27.1	84.3
Terrific	19.9	28.3	35.5	83.7
Enthusiastic	24.6	31.7	26.9	83.2
Awake	21	37.1	24.6	82.7
Warmed Up	21.3	26.8	34.1	82.2
Confident	25.9	27.1	28.9	81.9
Cheerful	34.5	29.8	17.3	81.6
Enough Time	15.1	29.5	36.7	81.3
Revived	25.1	25.1	30.5	80.7

Table 5. Items perceived to decrease exercise readiness.

Item	Percentage of Respondents Reporting			
	Slightly Decrease	Moderately Decrease	Strongly Decrease	Overall Decrease
Drained	26.9	26.9	35.3	89.1
Injured	15.7	23.5	49.4	88.6
Worn Out	32.1	28	26.8	86.9
Fatigued	28.6	28.8	28	84.6
Drowsy	34.3	30.1	19.9	84.3
Sick	10.9	24.2	49.1	84.2
Low Energy	30.7	33.7	19.3	83.7
Exhausted	19.3	30.1	34.3	83.7
Sleepy	28.1	26.9	28.1	83.1
Pain	25.5	25.5	30.9	81.9
No Time	22.9	23.5	34.9	81.3
Tired	26.8	31.5	22.6	80.9
Crummy	31.9	31.3	17.5	80.7
Lazy	32.7	24.2	23.6	80.5
Sluggish	38.9	25.7	15.6	80.2

Thus, an initial parallel analysis using a Monte Carlo simulation was conducted to determine the statistically significant eigenvalues to extract during the principal axis factor analysis. Syntax created by O'Connor (2000) was used to run the analysis in SPSS. Although only six of the 41 items were non-normally distributed, a permutation approach (recommended for non-normal data) was used as a conservative approach to generate random permutations (Ndatasets = 1000) from which to calculate competing eigenvalues, which has been found to be a more robust approach to conducting a parallel analysis (O'Connor, 2000). Raw data eigenvalues were considered significant (and thus, retained as factors) if they were larger than the 95th percentile eigenvalues and larger than the mean random data eigenvalues. The parallel analysis yielded four significant eigenvalues; Table 6 shows the results for all six eigenvalues greater than 1.0 in order to highlight how the parallel analysis distinguishes significant factors from those meeting the simple metric of an eigenvalue greater than 1.0. The MAP analysis, also using O'Connor's (2000) provided syntax, was in agreement with the parallel analysis and indicated four significant eigenvalues (data not shown).

Final factor analysis: Given the agreement between the parallel analysis and MAP, a second principal axis factor analysis with oblique rotation was run with extraction settings limited to four factors. These four factors (39 items) were found to explain 61.5% of the unrotated variance of exercise readiness. Items were considered loaded onto a factor if values exceeded .40 and were considered uniquely loaded if cross-loadings on other factors were less than .40 (Field, 2005). Factor 1 contained 22 items reflective of a state of vitality (e.g. lively, revived). Factor 2 contained 11 items related to a physical fatigued state (e.g. tired, drained). Factors 3 (4 items) and 4 (2 items) were descriptive of states of discomfort (e.g. pain, sick) and health (e.g. healthy, fit), respectively. Two items (awake, enough time) failed to significantly load on any of the four factors. A summary of the factor analysis is documented in Table 7.

Table 6. Parallel analysis results.

Initial Factors*	Raw Data Eigenvalue	Parallel Analysis Mean Eigenvalue	Parallel Analysis 95th Percentile Eigenvalue	Significant †
1	16.86	1.50	1.55	Yes
2	5.06	1.44	1.48	Yes
3	1.87	1.40	1.43	Yes
4	1.41	1.37	1.40	Yes
5	1.07	1.34	1.36	No
6	1.03	1.31	1.33	No

*Factors with Eigenvalues greater than 1.0 from initial exploratory factor analysis
†Significance determined if raw eigenvalue is greater than both the mean and the 95th percentile eigenvalues estimated by the parallel analysis

Table 7. Descriptive Statistics and Exploratory Factor Analysis (pattern matrix).

			Rotated Factor Loadings				
Item	**Mean**	**Standard Deviation**	**Communalities**	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
Inspired	4.14	1.65	.677	**.900**	.194	-.019	-.076
Cheerful	4.06	1.57	.755	**.891**	.066	-.057	-.064
Pumped	3.70	1.60	.755	**.882**	-.005	.134	-.047
Lively	3.99	1.47	.722	**.830**	-.062	.069	-.023
Terrific	3.88	1.58	.764	**.829**	-.085	-.009	-.082
Hyped	3.42	1.63	.657	**.826**	-.019	.241	-.104
Great	4.22	1.56	.771	**.819**	-.044	-.110	-.032
Positive	4.66	1.46	.684	**.791**	.153	-.247	.038
Happy	4.62	1.47	.642	**.779**	.131	-.246	-.040
Upbeat	3.96	1.46	.613	**.775**	.000	.011	-.085
Revived	3.65	1.52	.786	**.770**	-.233	.128	-.114
Motivated	4.48	1.52	.664	**.759**	.087	-.112	.003
Enthusiastic	2.83	1.49	.658	**.739**	-.029	.119	.045
Warmed Up	3.80	1.48	.556	**.712**	.001	.137	.007
Refreshed	3.70	1.47	.654	**.697**	-.237	.145	-.057
Determined	4.71	1.48	.576	**.692**	.162	-.129	.036
Active	4.10	1.70	.683	**.660**	.025	.035	.220
Fueled	3.91	1.46	.667	**.659**	-.237	.089	.008
Confident	4.63	1.54	.608	**.639**	.139	-.174	.208
Good	4.68	1.26	.570	**.604**	.082	-.204	.101
Strong	4.35	1.48	.673	**.588**	.086	-.060	.313
Energetic	2.91	1.53	.748	**.578**	-.253	.166	.220
Sleepy	4.03	1.78	.726	.113	**.913**	-.024	.011
Tired	4.14	1.71	.714	.043	**.899**	-.051	.032
Exhausted	3.61	1.76	.687	.068	**.803**	.098	-.044
Drained	2.72	1.79	.561	.021	**.751**	.002	.003
Drowsy	3.55	1.81	.566	.025	**.737**	.072	.052
Sluggish	3.65	1.71	.699	-.076	**.732**	.138	.017
Low Energy	3.80	1.66	.689	-.226	**.652**	.101	-.010
Fatigued	2.66	1.71	.465	-.009	**.622**	.100	.063
Worn Out	3.32	1.75	.530	.096	**.617**	.239	-.065
No Time	3.71	1.70	.388	.161	**.527**	.075	-.154
Lazy	3.83	1.72	.508	-.202	**.445**	.092	-.057
Awake	3.69	1.41	.447	.314	-.369	.061	.029
Pain	2.39	1.65	.508	.018	.192	**.690**	.093
Sick	2.36	1.71	.397	.020	.195	**.548**	-.026
Injured	1.87	1.48	.370	.018	.137	**.493**	.229
Crummy	2.92	1.60	.552	-.095	.375	**.480**	-.034
Fit	3.05	1.54	.587	.028	.006	.133	**.834**
Healthy	3.46	1.42	.624	.174	-.061	.080	**.691**
Enough Time	2.46	1.61	.364	.123	-.200	.133	.331
Initial Values			**% Variance**	41.12	12.35	4.55	3.45
			Eigenvalue	16.86	5.06	1.87	1.41
Rotated Values			**% Variance**	40.17	11.32	3.42	2.41
			Eigenvalue	15.54	10.39	3.11	6.51

Discussion

To our knowledge, this is the first study to empirically examine latent variables underlying the construct of exercise readiness, which may be an important construct to examine prior to assigning daily exercise workloads. Through a series of anonymous surveys distributed to University students enrolled in Kinesiology courses, exercise readiness-related items were systematically compiled, refined, and subjected to a robust exploratory factor analysis. Four, distinct latent variables emerged that represented the underlying construct of exercise readiness: vitality, physical fatigue, discomfort, and health.

Latent variables uncovered in the current study support recommendations highlighted by previous researchers for assessing exercise readiness within the context of FNLP. For example, Factor 1 (vitality) was comprised of words indicative of a positive mood and energized state, and explained the largest proportion of variance. This finding partially supports the approaches, utilized by McNamara and Stearne (2010, 2013), of assessing energy level alone or with mood state as primary indicators of readiness. Furthermore, it is likely that this affective phenomenon would influence the quality of interactions between the trainers and trainee, lending some support to Kraemer and Fleck's (2007) checklist. For example, positive mood is related to prosocial behaviors in the workplace (e.g. helpfulness with customers) (George, 1991) and a similar result would likely occur in the exercise context. Factors 2 (physical fatigue) and 3 (discomfort) directly mirror steps on Kraemer and Fleck's checklist related to rating mental/physical fatigue and assessment of injury status. Although hydration-related words were not ranked as high contributors to exercise readiness in the present study (and thus, not included in the factor analysis), poor hydration would likely be accounted for by physical fatigue and discomfort factors because common symptoms of dehydration include feeling tired and experiencing headaches or dizziness (Thomas et al., 2008). Further, it is likely that all four dimensions of exercise readiness found in the current study would interact and impact physical task performance and initial workload performance, which are two additional components on Kramer and Fleck's checklist. The current study is the first step toward developing a brief measure of exercise readiness. Once a structurally valid and reliable survey is created, further validation testing should consist of relating scores on a brief measure of exercise readiness to each step of Kraemer and Fleck's checklist.

In addition to lending support to the FNLP approaches mentioned above, the four factors are reflective of exercise barriers and determinants that have been expressed in the general, untrained populations. In regards to Factors 1 (vitality) and 2 (physical fatigue), lack of energy (Heesch et al., 2000; King et al., 2000), or feeling too tired (King et al., 2000) have been frequently cited as barriers to regular exercise. Factor 3 (discomfort) relates to previous research findings that experiencing medical conditions, injuries, or symptoms contribute to exercise attrition and low adherence (Heesch et al., 2000). Further, chronic pain has been found to contribute to avoidance behavior and low exercise levels (Philips, 1987; Vlaeyen and Linton, 2000). Finally, Factor 4 (health) was comprised of two items ("healthy" and "fit"). While considered a significant factor by the parallel analysis criteria, it is important to note that the initial eigenvalue was relatively small and explained approximately 3.5% of the unrotated variance. Although, it could have arguably been removed, this factor was kept in the model because a perception of good health has been considered in the literature as an important determinant of exercise behavior (Sallis and Hovell, 1990). Further, the current study's participants were young adults and perceived health status is likely to be a more important contributor of exercise readiness in older adults. Like injury status, poor health status has been shown to be a frequently cited barrier to physical activity in individuals over the age of 60 (Booth et al., 1997). Similarly, researchers have demonstrated that perceived fitness was a significant predictor of exercise behavior in older adults (Crombie et al., 2004). Considering the exploratory nature of this analysis, it is important for researchers to determine whether the four-factor dimensionality of exercise readiness found in the present study is consistent across samples with differing sociodemographic characteristics (e.g. age, disease state, socioeconomic status, educational status, etc.).

In addition to potential effects of different demographic characteristics, it would be important to determine how various psychological attributes impact influence item choice, retention, and factor clustering. In particular, readiness-related items and factors may differ based on positive or negative attitudes towards exercise. The Theory of Reasoned Action purports that attitudes toward a given behavior influence an individual's intention to act (Fishbein and Azjen, 2011). Thus, understanding inter-individual differences in attitudes may aid in further defining exercise readiness as a construct in various populations. For example, while "stressed" was most commonly listed as a signifier of low readiness in Stage 1, respondents in Stage 2 were relatively split regarding whether or not the feeling of being stressed would increase or decrease readiness to exercise (thus its exclusion from the final factor analysis). The paradox of physical exercise as a physiological stressor and modifier of stress responses is well documented (Hackney, A.C., 2006). It is possible that the perception of exercise as a stressor or stress reducer could be modified by one's attitude, such that individuals with very positive attitudes view exercise as a means of reducing stress (thus a marker of high readiness), whereas individuals with very negative attitudes would view exercise as yet another stressor (thus a marker of low readiness). This may potentially explain the lack of agreement in our sample as to whether feeling "stressed" increased or decreased readiness to exercise.

A greater understanding of exercise readiness (and demographic/psychosocial correlates thereof) is important because assessment of this construct has the potential to improve fitness testing and exercise prescription. Lower readiness as indicated by low vitality (Factor 1), elevated physical fatigue (Factor 2), discomfort (Factor 3), and/or poor perceptions of health/fitness (Factor 4) would likely reduce an individual's willingness and perceived ability to exert effort. Researchers have suggested assessing willingness to exert effort prior to maximal exercise testing (Midgley et al., 2007) because this and other psychological factors (e.g. task-specific determination, perceived competence in exertion tolerance, and physical self-efficacy) can influence perseverance during physical exertion (Tenenbaum et al., 2001). For example, if an individual were not able to put forth enough effort (e.g. due to residual muscle soreness) to reach maximal exertion criteria during a maximal exercise test, true fitness levels would be underestimated. Additionally, low readiness could potentially elevate perceived in-task exertion at a given exercise intensity (i.e., perception of having to "work harder" to complete a given task) and higher perceived exertion is inversely related to in-task affective valence (i.e., feelings of pleasure vs. displeasure) (Welch et al., 2007). This is problematic because less pleasurable feelings during a single exercise bout have been shown to be predictive of lower levels of physical activity in the future (Williams et al. 2008; 2012). Thus, by measuring exercise readiness, researchers and practitioners could make appropriate decisions to help avoid low-quality testing or negative exercise experiences. In this regard, the findings of current study support the potential to assess exercise readiness with a brief measure that also considers the multidimensionality of this construct.

The current research is not without limitations. A primary limitation is only surveying University students. It is possible that demographic characteristics (age, health status, socioeconomic status, etc.) influence an individual's definition of exercise readiness. In that regard, further research is warranted to compare the current findings with those observed in other sample populations. Additionally, correlations on the basis of factor analysis describe relationships and; thus, no causal inferences can be made from these correlations alone. Despite these limitations, the current study has several notable strengths, including a high level of diversity in respondent ethnicity and physical activity level, the use of statistically sound methods to determine number of significant factors, and sufficient sample size (16 cases per parameter estimate).

Conclusion

The present study was the first phase in developing a brief measure of exercise readiness. The purpose of the current study was to empirically explore the dimensionality of exercise readiness. Furthermore, the results herein provide a preliminary foundation to design a brief measure of exercise readiness that would undergo structural validity testing using confirmatory factor analysis procedures. The researchers utilized an inductive approach (i.e. "bottom up" identification of relevant items by lay individuals and subsequent exploratory analyses to identify, rather than confirm, factor structure) in the present study to determine latent variables of exercise readiness. Because this approach resulted in a factor structure that shares similarities with practical approaches and common exercise barriers, subsequent survey design should rely on a deductive approach, wherein experts determine easily understood, "prototypical" items that best represent each factor (vitality, physical fatigue, discomfort, health) in order to construct a brief and highly communicable measure of exercise readiness. Therefore, the next phase of this endeavor (construction and validation of a brief measure of exercise readiness based upon this initial theoretical foundation) is currently underway.

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Key points

- Assessment of exercise readiness is a key component in implementing an exercise program based on flexible nonlinear periodization, but the dimensionality of this concept has not been empirically determined.
- Based on a series of surveys and a robust exploratory factor analysis, exercise readiness appears to be supported by 4 dimensions: vitality, physical fatigue, discomfort, and health.
- These findings prove a theoretical basis to construct a brief, multidimensional measure of exercise readiness.

AUTHOR BIOGRAPHY

Kelley STROHACKER

Employment

Assistant Professor at the University of Tennessee.

Degree

PhD

Research interests

Intervention development, particularly in regards to adapting flexible nonlinear periodization for use in sedentary, at-risk populations.

E-mail: kstrohac@utk.edu

Rebecca ZAKRAJSEK
Employment
Assistant Professor at the University of Tennessee.
Degree
PhD
Research interests
Applied sport psychology, particularly in regards to coaches' perceptions and use of sport psychology services.
E-mail: raz@utk.edu

✉ **Kelley Strohacker**
1914 Andy Holt Ave., 338 HPER Bldg Knoxville, TN 37996-2700, USA