

Confirmatory Factor Analysis of the Disablement in the Physically Active Scale and Preliminary Testing of Short-Form Versions: A Calibration and Validation Study

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Context: The Disablement in the Physically Active (DPA) scale is a patient-reported outcome instrument recommended for use in clinical practice and research. Analysis of the scale has indicated a need for further psychometric testing.

Objective: To assess the model fit of the original DPA scale using a larger and more diverse sample and explore the potential for a short-form (SF) version.

Design: Observational study.

Setting: Twenty-four clinical settings.

Patients or Other Participants: Responses were randomly split into 2 samples: sample 1 ($n = 690$: 353 males, 330 females, and 7 not reported; mean age = 23.1 ± 9.3 years, age range = 11–75 years) and sample 2 ($n = 690$: 351 males, 337 females, and 2 not reported; mean age = 22.9 ± 9.3 years, age range = 8–74 years). Participants were physically active individuals who were healthy or experiencing acute, subacute, or persistent musculoskeletal injury.

Main Outcome Measure(s): Confirmatory factor analysis was conducted to assess the factor structure of the original DPA scale. Exploratory factor, internal consistency, covariance

modeling, correlational, and confirmatory factor analyses were conducted to assess potential DPA scale SFs.

Results: The subdimensions of the disablement construct were highly correlated (≥ 0.89). The fit indices for the DPA scale approached recommended levels, but the first-order correlational values and second-order path coefficients provided evidence for multicollinearity, suggesting that clear distinctions between the disablement subdimensions cannot be made. An 8-item, 2-dimensional solution and a 10-item, 3-dimensional solution were extracted to produce SF versions. The DPA SF-8 was highly correlated ($r = 0.94$, $P \leq .001$, $R^2 = 0.88$) with the DPA scale, and the fit indices exceeded all of the strictest recommendations. The DPA SF-10 was highly correlated ($r = 0.97$, $P \leq .001$, $R^2 = 0.94$) with the DPA scale, and its fit indices values also exceeded the strictest recommendations.

Conclusions: The DPA SF-8 and SF-10 are psychometrically sound alternatives to the DPA scale.

Key Words: measurement, covariance modeling

Key Points

- The Disablement in the Physically Active (DPA) scale Short Form-8 (SF-8) and Short Form-10 (SF-10) are psychometrically sound generic patient-reported outcome instruments for the physically active.
- Scoring and evaluating the individual summary components of the DPA SF-8 and SF-10, as opposed to using a cumulative summary score across dimensions, may be more effective for research and practice.
- The DPA SF-8 offers improved model fit, precision, and reduced response burden compared with the SF-10.

Evidence-based practice (EBP) involves the development of practice standards based on the collection, appraisal, interpretation, and application of the research literature to guide clinical practice.¹ Although evidence is often associated with the published peer-reviewed research literature, the EBP process also includes consideration of personal clinical expertise and experience, along with the patient's specific situation (eg, needs, beliefs, circumstances), to make the most appropriate health care decision for a given patient in a specific situation.² In clinical practice, this may be accomplished through the systematic collection and assessment of patient outcomes. Patient outcomes may be collected using clinician-derived measures (eg, strength measurements)³

or patient self-report instruments.^{4,5} Often, this process is conducted using patient-reported outcome (PRO) scales that measure patient-, disease-, region-, or domain-specific constructs regarding the patient's condition.^{5–9}

Patient-reported outcome scales may be unidimensional, but many are designed as multidimensional instruments for measuring physical and psychological constructs that capture the injury and recovery process experienced by a patient.^{8,10–12} The purpose of PRO instruments is to use patients' perceptions to measure aspects of the injury and recovery process that are meaningful to them.¹³ Multidimensional PRO instruments are often designed as region-specific scales (eg, Lower Extremity Functional Scale) or generic instruments that are not specific to a part of the

body or type of injury.^{4,14,15} A common construct measured with the generic instruments is health-related quality of life (HRQoL). Health-related quality of life is valued as a construct because it is thought to encompass patients' perceptions of physical, psychological, and social subconstructs of their health status and recovery.^{14,16}

A variety of generic instruments are available to assess HRQoL. Two of the more commonly used generic PROs are the Short-Form 36 (SF-36) and the Short-Form 12.¹⁷ However, both instruments have limitations in certain situations. For example, the instruments were not designed for assessing HRQoL after musculoskeletal injury in physically active populations.^{17–19} Additionally, the instruments do not adequately distinguish between “causal indicators” (eg, impairment, mood) of HRQoL and a true assessment of life quality.^{20–22} As a result, the Disablement in the Physically Active (DPA) scale was created to measure HRQoL as a unique construct while assessing 3 theorized subdimensions of the disablement process: impairment, functional limitations, and disability.^{14,15} The DPA scale is a 16-item instrument, scored on a 1 (*no problem*) to 5 (*severely affected*) Likert scale, with a total score floor of 0 and a ceiling of 64 points.¹⁵ The scale has been reported to have acceptable model fit (χ^2 statistic/degrees of freedom ratio [CMIN/DF] = 1.89, Goodness of Fit Index [GFI] = 0.852, Tucker-Lewis Index [TLI] = 0.924, Comparative Fit Index [CFI] = 0.937, root mean square error of approximation [RMSEA] = 0.085),¹⁵ high test-retest reliability (intraclass correlation coefficient = 0.943) and internal consistency (α = .890–.908),²³ and concurrent validity (–0.751 [acute] and –0.710 [persistent] relationship with global functioning scores).¹⁵ The DPA scale also has similar summary components as the SF-36.²⁴ The design and results of early psychometric measurement evaluation have led to the scale being recommended for use in research and practice.^{15,23,24}

Yet certain potential limitations should be considered when using the DPA scale in clinical research and practice. The confirmatory factor analysis (CFA) was performed with data from only 125 participants who were all currently injured (ie, 43 reported injury at baseline, 28 were postacute injury, and 54 reported persistent injury), coming from the same geographic regions (5 sites), and in a similar age range (ie, high school and collegiate athletes).¹⁵ Based on structural equation modeling standards,^{25,26} the sample was small and homogeneous, suggesting that further assessment is needed before the instrument is widely used in clinical practice and research across heterogeneous, physically active populations. Overall, the samples studied during previous psychometric measurement analyses make it difficult to fully assess the fit indices or determine if the scale structure would remain sound among larger, more diverse samples.^{25,26}

Additionally, although some recommended cut points for fit indices^{15,27} were met when scale structure was assessed in the original study, other instrument structure concerns remain. For example, stricter fit indices have been recommended for establishing acceptable model fit, such as RMSEA ≤ 0.06 ²⁸ and TLI, GFI, and CFI ≥ 0.95 .²⁹ Furthermore, the 3 proposed subdimensions of disablement (ie, impairment, functional limitation, and disability) were highly correlated (>0.90),¹⁵ and the high correlational values may indicate the items are not effectively measuring

unique subdimensions.²⁶ For example, a follow-up study²⁴ of the DPA scale produced only 2 summary components: (1) physical summary (ie, items 1–12 of the impairment, functional limitation, and disability subdimensions) and (2) mental summary (items 13–16 of the quality of life construct). These findings demonstrate the need for additional testing of the DPA scale and its summary components in a larger sample that better represents the patient population (eg, different geographic locations and activity levels).^{15,24,26}

Further analysis should also be conducted to determine if a more concise version of the scale exists to satisfactorily measure the disablement process based on the proposed items and constructs. Removing items with low construct validity may improve its overall precision and reduce measurement error without overlooking important patient-reported information on the disablement process.^{25,30} In general, more concise and simpler models are preferred,²⁵ and more concise versions may produce scales with improved validity, precision, and applicability in research and practice.^{30–33} The DPA scale was designed as a generic PRO to be used across a diverse, physically active population experiencing musculoskeletal injuries. However, the scale has primarily been assessed by studying collegiate athletes in similar geographic locations.^{14,15,23,24} Therefore, the construct validity of the DPA scale must be assessed among a more diverse sample of the physically active population that can be expected to use the scale across multiple health care disciplines.^{25,26} Further psychometric testing is justified for refining the DPA scale, and caution should be used when interpreting the findings of the instrument until further assessment has been completed.

Thus, the purposes of our study were to (1) assess the model fit of the original DPA scale using a larger and more diverse sample to examine its psychometric properties, (2) explore the potential for a short-form (SF) version, and (3) assess the psychometric properties of any proposed SF versions of the DPA scale to examine whether model fit was maintained in a second sample of physically active participants. The first objective was to use CFA to assess the fit of the originally proposed model of the DPA scale and correlational values among the proposed subdimensions of the instrument. The second objective was to use exploratory factor analysis (EFA) to identify alternative SF versions of the DPA scale to improve model fit. The third objective was to use covariance modeling to further assess the structural validity of the measurement models extracted from the EFA. The final objective was to use CFA to assess the fit of any proposed SF versions of the DPA scale.

METHODS

Participants

After institutional review board approval of this project was granted, participants reviewed and provided informed consent before completing the DPA scale. In the case of minors, the participant provided assent, while the legal guardian provided consent. Participants were recruited from athletic training clinics ($n = 22$) and outpatient rehabilitation clinics ($n = 2$) across the United States. Participants were free of chronic pain,^{15,34} and injuries were classified based on a priori definitions for each category into 4

Table 1. Inclusion and Exclusion Criteria for Physical Activity and Injury^a

Criterion	Definition ¹⁵
Inclusion	
Physically active and	An individual who engages in athletic, recreational, or occupational activities that require physical skills and who uses strength, power, endurance, speed, flexibility, range of motion, or agility at least 3 d/wk
Healthy or	Free from musculoskeletal injury and fully able to participate in sport or activity
Acute injury or	A musculoskeletal injury that precludes full participation in sport or activity for at least 2 consecutive d (0–72 h postinjury)
Subacute injury or	A musculoskeletal injury that precludes full participation in sport or activity for at least 2 consecutive d (3 d to 1 mo postinjury)
Persistent injury	A musculoskeletal injury that has been symptomatic for at least 1 mo
Exclusion	
Chronic pain	Pain that consistently does not get any better with routine treatment or nonnarcotic medication ¹⁵

^a Adapted with permission.¹⁵

groups: healthy, acute injury, subacute injury, and persistent injury (Table 1). Activity levels of participants were also classified according to a priori definitions to create 4 groups: competitive athletes, recreational athletes, occupational athletes, and nonathletes who were physically active in activities of daily living (Table 2). A total of 1592 participants completed the study. Data from the entire sample were cleaned and dichotomized into 2 random subsamples of equal size for use in the calibration (sample 1) and validation (sample 2) phases of the study.

Instrumentation

Participants completed packets that included the DPA scale and demographic questions at an initial intake session with the athletic trainer (AT). We hypothesized that the DPA scale had 4 first-order factors assessed by 16 items. The primary 3 factors, impairments, functional limitations, and disability, were hypothesized to comprise the second-order construct of disablement. Items 1 to 4 were designed to tap into the impairment dimension, items 5 to 9 into the functional limitations construct, and items 10 to 12 into the disability construct. Items 13 to 16 were designed to address the construct of quality of life, which covaries with disablement. Each item was rated on a 1 (*no problem*) to 5 (*severely affected*) Likert scale. The scores for each item are summed to create a composite score, and 16 points are subtracted from the summed total to obtain the final value. Scores range from 0 (ie, floor) to 64 (ie, ceiling) points.¹⁵

The AT working with the participant also collected demographic information, including injury category (ie, persistent, acute, subacute, or healthy), patient athletic status (eg, competitive athlete, recreational athlete), age, sex, sport, general injury location (ie, lower extremity, spine, and upper extremity), specific injury location (eg, head/neck, shoulder/arm, ankle/foot), and type of injury (eg, arthritis, neuroma, strain, sprain, postsurgery; Tables 3–5). If a patient had difficulty understanding an item on

Table 2. Participant Athletic Status Definitions^a

Status	Definition
Competitive athlete	A participant who engages in a sport activity that requires at least 1 preparticipation examination, regular attendance at scheduled practices and/or conditioning sessions, and a coach who leads practices and/or competitions
Recreational athlete	A participant who meets the criteria for physical activity and participates in sport but does not meet the criteria for competitive status
Occupational athlete	A participant who meets the criteria for physical activity for occupation or recreation but does not meet the criteria for competitive or recreational athlete
Physically active in activities of daily living	A participant who does not meet the criteria for any athlete category but who is physically active through daily activities (eg, physically active for at least 30 min/d for 3 d/wk)

^a Adapted with permission.¹⁵**Table 3. Participant-Reported Primary Sport Activity**

Sport	Frequency (%) ^b	
	Sample 1a (n = 690)	Sample 2a (n = 690)
Baseball	41 (5.9)	32 (4.6)
Basketball	54 (7.8)	62 (9.0)
Cheerleading	9 (1.3)	7 (1.0)
Cross-country	23 (3.3)	12 (1.7)
Cycling	3 (0.4)	2 (0.3)
Dance	21 (3.0)	19 (2.8)
Field hockey	2 (0.3)	3 (0.4)
Football	73 (10.6)	77 (11.2)
Golf	3 (0.4)	2 (0.3)
Gymnastics	1 (0.1)	1 (0.1)
Ice hockey	2 (0.3)	3 (0.4)
Lacrosse	57 (8.3)	62 (8.9)
Martial arts	1 (0.1)	0 (0.0)
Racquet sports	7 (1.0)	10 (1.4)
Recreational running	49 (7.1)	55 (8.0)
Rock climbing	3 (0.4)	1 (0.1)
Rodeo	4 (0.6)	1 (0.1)
Roller derby	2 (0.3)	0 (0.0)
Rugby	10 (1.4)	16 (2.3)
Skiing/snowboarding	2 (0.3)	3 (0.4)
Soccer	78 (11.3)	80 (11.6)
Softball	9 (1.3)	18 (2.6)
Swimming/diving	10 (1.4)	9 (1.3)
Track and field	32 (4.6)	28 (4.1)
Triathlete	3 (0.4)	1 (0.1)
Tennis	4 (0.6)	2 (0.3)
University fitness classes	14 (2.0)	21 (3.0)
Volleyball	24 (3.5)	20 (2.9)
Water polo	6 (0.9)	4 (0.6)
Wrestling	7 (1.0)	9 (1.3)
Weight lifting (eg, CrossFit ^a)	32 (4.6)	36 (5.2)
Other (eg, walking, yoga, exercise classes, Reserve Officers' Training Corps, employment)	92 (13.3)	37 (5.4)
Not reported	12 (1.7)	57 (8.3)

^a CrossFit, Inc, Washington, DC.^b The sum does not equal 100% because percentages were rounded.

Table 4. Clinician-Reported Injury Locations

Injury Location	Frequency (%)	
	Sample 1a (n = 690)	Sample 2a (n = 690)
Head/neck	27 (3.9)	36 (5.2)
Shoulder/arm	82 (11.9)	64 (9.3)
Elbow/forearm	8 (1.2)	12 (1.7)
Wrist/hand	21 (3.0)	15 (2.2)
Trunk/thoracic spine	16 (2.3)	24 (3.5)
Low back/pelvis	68 (9.9)	61 (8.8)
Hip/thigh	63 (9.1)	73 (10.6)
Knee/leg	157 (22.8)	155 (22.5)
Ankle/foot	120 (17.4)	129 (18.7)
Other	9 (1.3)	5 (0.7)
Not reported	119 (17.2)	116 (16.8)

the DPA scale, the attending AT could explain the term or phrase (eg, *cardiovascular endurance*) to the participant, as this would naturally occur in the process of providing effective patient-centered care.

Data Analysis

The DPA scale responses and demographic information were deidentified and entered into Qualtrics software (Qualtrics LLC, Provo, UT) by the collecting AT. Data were downloaded from Qualtrics for analyses using SPSS (version 24; IBM Corp, Armonk, NY) and Analysis of Moment Structure (AMOS; version 24; SPSS Inc, Chicago, IL). Missing data were treated conservatively, and any participant response with a missing value for the DPA scale was removed from the dataset. Missing demographic data were left as missing values. Data analysis and cleaning were conducted on the univariate distributions of all the variables to verify whether they were normally distributed with low levels of skewness and kurtosis. Multivariate outliers were identified using descriptive statistics and Mahalanobis distance.^{35–37}

Confirmatory Factor Analysis of the DPA Scale. Confirmatory factor analysis (CFA) was conducted using AMOS on the DPA scale to assess model fit. Consistent with the original assessment of the scale, the DPA scale was specified as a 5-factor (1 second-order and 4 first-order factors), 16-item model¹⁵ to assess model fit. Maximum likelihood estimation was used to generate parameter estimates. The likelihood ratio statistic (CMIN), CMIN/DF, GFI, CFI, TLI, RMSEA, and Bollen Incremental Fit Index (IFI) were used to assess model fit. Because the χ^2 test is sensitive to sample size, increasing the likelihood of misrepresenting model fit,²⁷ this test carried less weight when we assessed model fit. The fit indices used to assess model fit were set based on the following a priori values: GFI \geq 0.95,³⁵ CFI \geq 0.95, TLI \geq 0.95, RMSEA \leq 0.06,²⁹ and IFI \geq 0.95.²⁷ Additionally, R^2 values \geq 0.90 for latent variable correlations and path coefficient values were used to identify multicollinearity among the latent variables and determine potential dimensions in which scale item removal might be beneficial to prevent model misspecification.^{25,27}

Identification and Calibration Analysis of SF Versions of the DPA Scale. To identify possible SF versions of the DPA scale, we conducted EFA using maximum likelihood extraction with oblimin rotation on the 16 items designed to assess the 4 factors. Factorability of the data was

Table 5. Clinician-Reported Injury Type

Injury Type	Frequency (%) ^a	
	Sample 1a (n = 690)	Sample 2a (n = 690)
Arthritis	5 (0.7)	10 (1.4)
Dislocation/subluxation	27 (3.9)	29 (4.2)
Disc pathologic condition	23 (3.3)	19 (2.8)
Fracture	9 (1.3)	8 (1.2)
Meniscal/labral lesion	29 (4.2)	26 (3.8)
Neuroma	2 (0.3)	3 (0.4)
Postsurgery	14 (2.0)	17 (2.5)
Sprain	158 (22.9)	161 (23.3)
Strain	133 (19.3)	134 (19.4)
Stress fracture	26 (3.8)	16 (2.3)
Tendinopathy	68 (9.9)	68 (9.9)
Other	80 (11.6)	82 (11.9)
Not reported	116 (16.8)	117 (17.0)

^a The sum does not equal 100% because percentages were rounded.

determined by the (a) Kaiser-Meyer-Olkin test = 0.80 (recommended value $>$ 0.70) and (b) Bartlett test of sphericity $P <$.001 (recommended value $<$.05).³⁶ After estimation, we specified the measurement model, eliminating items if they (a) did not have substantial loadings (\geq 0.50), (b) had simultaneous, substantial cross-loadings (\geq 0.30), or (c) did not fit conceptually with the other items loading on the factor. Factor dimensions were extracted based on either an eigenvalue $>$ 1.0 or accounting for more than 5% of variance.³⁶ To assess internal consistency and to ensure factor parsimony (ie, including only the items necessary to reliably measure the construct), Cronbach α was estimated with an acceptable a priori value of \geq 0.70 and \leq 0.89.³⁶

Covariance modeling, using AMOS and maximum-likelihood estimation procedures, was conducted on any proposed SF versions of the DPA scale to assess model fit. To assess model fit, the same tasks and criteria used for the CFA were applied to this analysis. The measurement model specified within the covariance modeling analysis was consistent with the measurement model extracted from the EFA.

Correlational analyses were conducted between the scores on the proposed SF versions of the DPA scale and the original DPA scale. Pearson correlations were estimated to determine if the SF versions explained an acceptable percentage of the variance (ie, $r \geq$ 0.90 [$R^2 = 0.81$]) in responses to the original DPA scale.³⁰

Validation Analyses of the DPA Scale SFs. Following the procedures previously described, we conducted a CFA for each of the proposed SF versions of the DPA scale using data from the validation sample. The cumulative scores for each SF version were then correlated with the score for the original DPA scale to determine if the SF versions explained an acceptable amount of variance (ie, $r \geq$ 0.90 [$R^2 = 0.81$]) in responses on the original DPA scale.³⁰

RESULTS

Preliminary Analysis

Within the entire sample (n = 1592), 100 participants (6%) did not complete the entire DPA scale and were removed from the dataset. A total of 112 (7%) participants

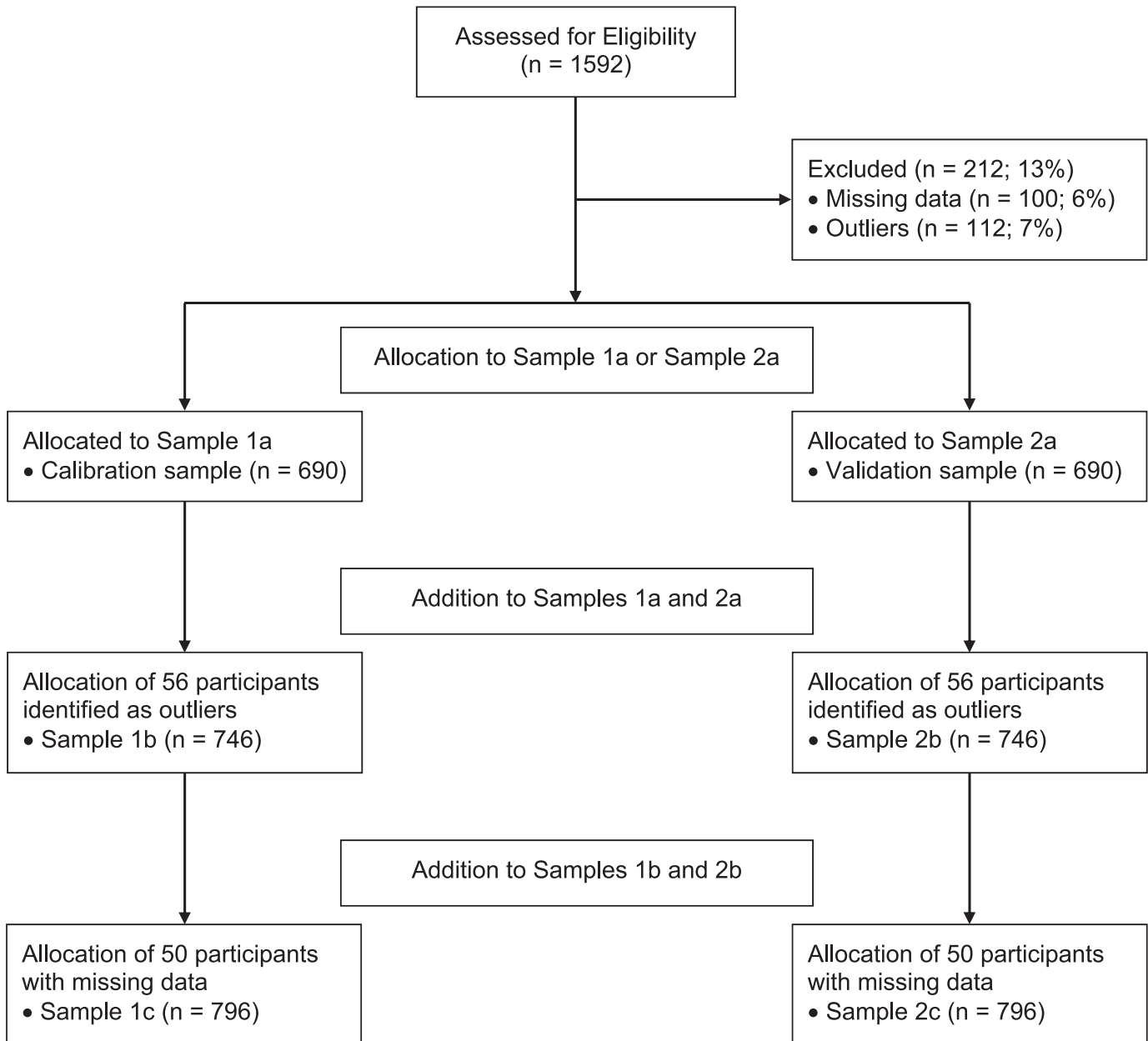


Figure 1. Participant allocation across calibration and validation samples.

reported scores that were identified as univariate (z scores ≥ 3.4) or multivariate (Mahalanobis distance ≥ 33) outliers.³⁷ These participants included both sexes, all injury categories (eg, acute, persistent), and various injury types (eg, sprain, strain). Removing these participants from the sample resulted in a normal data distribution for both individual items and summary indexes of the items. A total of 1380 (87%) participants remained, and they were randomly split into 2 even samples ($n = 690$ for sample 1a and $n = 690$ for sample 2a) for the calibration and validation phases of the study (Figure 1).

Given the substantial number of participants removed using the data-cleaning process, it was valuable to ensure that the model fit achieved was not a result of bias due to participant removal. Thus, an equal and random sample ($n = 56$) of the participants identified as outliers was added

back to each sample ($n = 746$ for sample 1b and $n = 746$ for sample 2b). An equal and random sample ($n = 50$) of participants with missing data was also added back to each sample ($n = 796$ for sample 1c and $n = 796$ for sample 2c). Samples 1a and 2a were used for the primary analyses in this study. The final models (Figure 1) were then re-estimated using samples 1b and 2b and 1c and 2c, and the findings were compared with those from samples 1a/2a to ensure consistency in findings across the samples. Because samples 1c and 2c contained missing data, we conducted the analyses on these samples using full-information maximum-likelihood estimation. This technique was used because parameter estimation can occur without the deletion of participants or the imputation of missing values, while also providing less biased parameter estimates than other previously used methods.^{25–27}

A total of 690 participants were included in sample 1a (353 males, 330 females, 7 sexes not reported; mean age = 23.1 ± 9.3 years, age range = 11–75 years), which consisted of competitive athletes ($n = 337$, 48.8%), recreational athletes ($n = 168$, 24.3%), occupational athletes ($n = 158$, 22.9%), and nonathletes who were physically active through activities of daily living ($n = 27$, 3.9%). Participants reported being active in a variety of primary sports (Table 3). The majority of responses ($n = 428$, 62.0%) were collected at collegiate (Division I = 67, 9.7%; Division II = 126, 18.3%; Division III = 32, 4.6%; National Association of Intercollegiate Athletics = 63, 9.1%; junior college = 44, 6.4%) and high school ($n = 96$, 13.9%) athletic training clinics, but a large portion of the sample data ($n = 263$, 38.1%) was collected in 2 outpatient clinics. The sample consisted of healthy participants ($n = 127$, 18.4%) as well as those with persistent injury ($n = 220$, 31.9%), acute injury ($n = 144$, 20.9%), and subacute injury ($n = 199$, 28.8%). A variety of injury locations (Table 4) and types were reported (Table 5).

Sample 2a consisted of 351 males, 337 females, and 2 who did not report sex. The sample (mean age = 22.9 ± 9.3 years, age range = 8–74 years) included participants classified into all 4 activity statuses who reported involvement in a variety of primary sports (Table 3). A total of 338 (49.0%) participants were classified as competitive athletes, 176 (25.5%) as recreational athletes, 164 (23.8%) as occupational athletes, and 12 (1.7%) as nonathletes who were physically active through activities of daily living. Participants were classified as healthy ($n = 122$, 17.7%) or experiencing persistent injury ($n = 219$, 31.7%), acute injury ($n = 156$, 22.6%), or subacute injury ($n = 193$, 28.0%). For those who were injured, a variety of injury locations (Table 4) and types (Table 5) were reported by their treating clinicians. The majority of responses from participants were collected in the traditional athletic training setting ($n = 442$, 64.1%) at collegiate (Division I = 64, 9.3%; Division II = 123, 17.8%; Division III = 40, 5.8%; National Association of Intercollegiate Athletics = 68, 9.9%; junior college = 46, 6.7%) and high school ($n = 101$, 14.6%) athletic training clinics. A total of 248 (35.9%) responses were collected from participants seeking care in outpatient clinic settings.

Scale Structure of the DPA Scale

The correlations between the subdimensions of the disablement construct were high (impairment and functional limitations $r = 0.95$, functional limitations and disability $r = 0.97$, impairments and disability $r = 0.89$). Because of the high correlations, as researchers¹⁵ did in the original assessment of the DPA scale, we used a hierarchical CFA to assess the scale structure of the originally published model. The initial analysis revealed fit indices approaching acceptable levels (GFI = 0.903, CFI = 0.938, TLI = 0.926, RMSEA 0.082, IFI = 0.938) but indicated the standardized path coefficient between the higher-order disablement construct and the subconstruct of functional limitations was >1 . As was the case in the initial analysis of the scale,¹⁵ the modification indices indicated the model fit could be improved if the error covariance between items 5 and 9 and between items 8 and 12 was free to covary. Because we were assessing the findings of the original

analysis, we accepted these specifications. For the final model ($\chi^2_{98} = 420.849$, CMIN/DF = 4.294, $P < .001$), the CFI (0.957) and IFI (0.957) fit indices were above the recommended levels. The GFI (0.929), TLI (0.947), and RMSEA (0.069) approached recommended levels, but the standardized path coefficient between the higher-order disablement construct and the subconstruct of functional limitations remained > 1 (Figure 2). The high correlational values between the latent variables and a path coefficient score > 1 suggested the presence of multicollinearity among the latent variables, as well as model misspecification, which supported testing the removal of items to improve model fit.^{25–27}

Scale Structure of the Short-Form Versions of the DPA Scale

Exploratory Factor Analysis Results. A 2-factor structure emerged from the EFA of the DPA scale items. The first factor represented a physical summary component (items 1–12), whereas the second factor represented a mental (QOL) summary component (items 13–16). The total variance accounted for by the items in the 2 factors was 60%, with the physical summary component accounting for 49% of the variance (eigenvalue = 7.86; $\alpha = .945$), and the QOL component accounting for 11% of the variance (eigenvalue = 1.73; $\alpha = .852$). Using higher cross-loading values, Cronbach α , and latent variable R^2 values as a guide, the 16-item, 2-factor solution was reduced to an 8-item instrument with shortened physical (items 1, 2, 3, and 5) and QOL (items 13–16; Table 6) summary components. The factors within the shortened version accounted for a similar proportion of the variance (total = 61%; physical summary = 43.95%; mental summary = 16.58%). Cronbach α was improved from the original scale structure, with the new solution having acceptable internal consistency values for the physical summary factor ($\alpha = 0.850$) and the QOL factor ($\alpha = 0.852$), while also resolving the possible multicollinearity between latent variables ($r = 0.45$, $R^2 = 0.20$).

A 3-factor solution could also be specified from the EFA (Table 7). The first factor represented impairment (items 1–3), the second factor represented QOL (items 13–16), and the third factor represented functional limitations (items 4, 5, and 9). The total variance accounted for by the 3-factor solution was 63%, with impairment accounting for 44.5%, QOL accounting for 15%, and functional limitations accounting for 3.5%. The items comprising the 3-factor solution improved Cronbach α levels across dimensions, with impairment ($\alpha = 0.837$), functional limitations ($\alpha = 0.840$), and QOL ($\alpha = 0.850$) having acceptable internal consistency. The items in each scale, along with the original and revised dimension labels, are provided in Table 8. The Cronbach α indicated reduced redundancy. Correlation values were reduced below $r = 0.95$ ($R^2 \leq 0.89$); however, the correlations between dimensions were high enough (ie, ≥ 0.90) to indicate multicollinearity may still be present in the solution.^{25–27}

Covariance Modeling Results. Initial fit of the covariance model to the 2-factor, 8-item (ie, DPA SF-8) solution indicated excellent fit ($\chi^2_{19} = 36.949$, CMIN/DF = 1.945, $P = .008$), with fit indices exceeding recommended levels (GFI = 0.987, CFI = 0.993, TLI = 0.990, RMSEA 0.037, IFI

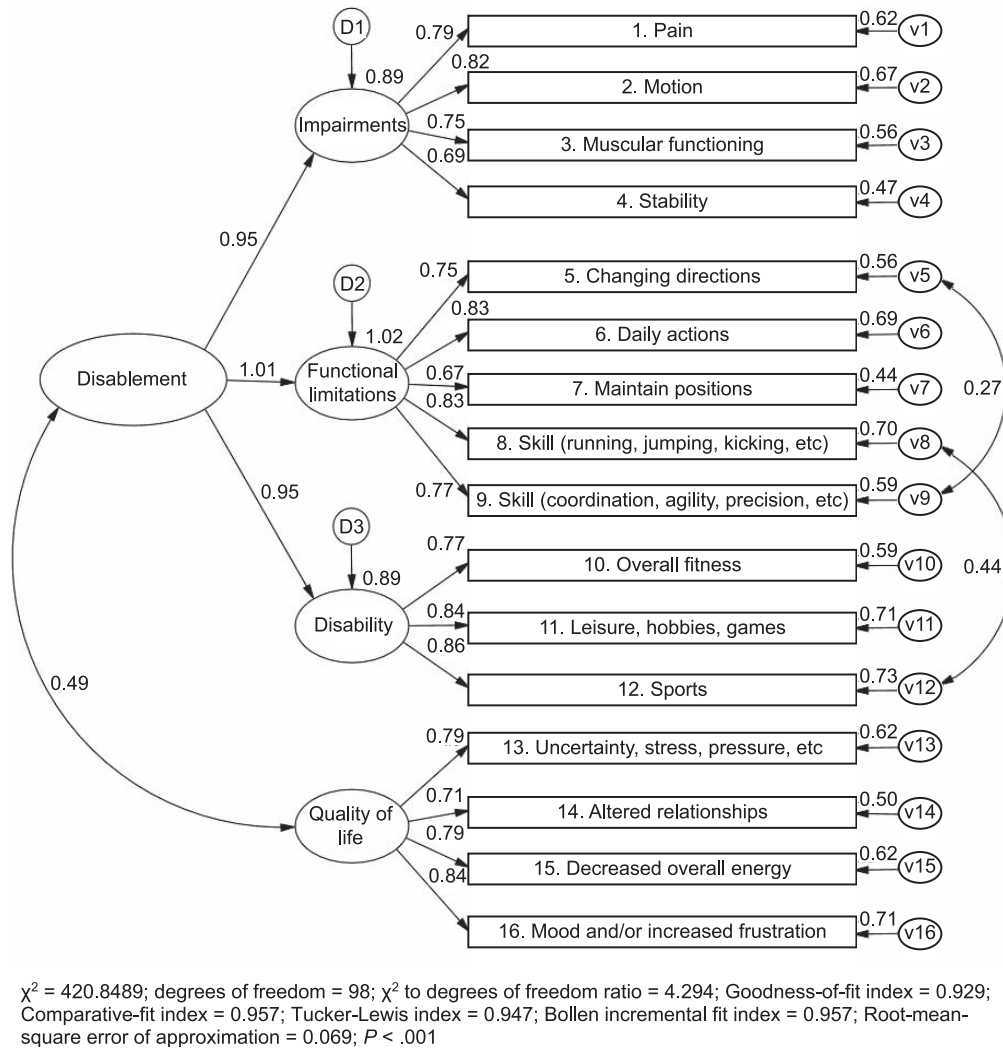


Figure 2. The Disabling in the Physically Active scale hierarchical confirmatory factor analysis measurement model with standardized loadings for sample 1a (n = 690). Abbreviation: v, unique variance. Adapted with permission.¹⁵

= 0.993; Figure 3). All factor loadings were significant ($P \leq .001$), and modification indices did not suggest that model fit could be substantially improved with the specification of a covariance between error terms.

Initial covariance modeling of the DPA SF-10 indicated the correlation between impairment and functional limitations constructs was high ($r = 0.83$) and acceptable between functional limitations and quality of life ($r = 0.26$) and between impairment and quality of life ($r = 0.45$). Because of the high correlations, a second-order model was used to assess the scale structure of the DPA SF-10. The initial analysis revealed that fit indices exceeded the recommended levels ($\chi^2_{32} = 60.911$, CMIN/DF = 1.903, $P = .002$, GFI = 0.983, CFI = 0.992, TLI = 0.989, RMSEA = 0.036, IFI = 0.992). The modification indices indicated the model fit could be slightly improved if the error covariance between unique variance 5 and unique variance 9 was free to covary. Because improvement was nonsignificant and all factor loadings were significant ($P \leq .001$), the DPA SF-10 measurement model without this modification was accepted (Figure 4). A comparison of the final model solutions for the DPA scale, DPA SF-10, and DPA SF-8 across all samples (1a, 1b, and 1c) is provided in Table 9.

Scale Correlation Results. The correlation between the participants' cumulative scores on the DPA scale and the DPA SF-8 was high ($r = 0.94$, $P \leq .001$, $R^2 = 0.88$). The correlations between participant cumulative scores on the DPA scale and the DPA SF-10 ($r = 0.97$, $P \leq .001$, $R^2 = 0.94$) and between cumulative scores on the DPA SF-10 and the DPA SF-8 ($r = 0.98$, $P \leq .001$, $R^2 = 0.96$) were high. Group mean scores on the 3 versions of the scale are provided in Table 10.

Confirmatory Factor Analysis Results of the DPA Scale SF-8 and SF-10

The fit for the CFA of the DPA SF-8 indicated excellent fit ($\chi^2_{19} = 29.459$, CMIN/DF = 1.550, $P = .06$) because all of the assessed fit indices exceeded the recommended levels (GFI = 0.989, CFI = 0.996, TLI = 0.994, RMSEA = 0.028, IFI = 0.996; Figure 5). The factor loadings were all significant ($P \leq .001$), and the model fit could not be substantially improved with the specification of a covariance between error terms.

Initial analysis of the covariance model of the DPA SF-10 indicated the correlation between the impairment and

Table 6. Exploratory Factor Analysis Pattern Matrix Loadings for the DPA Short Form-8^a

Item ^{b,c}	Maximum Likelihood	
	Physical Summary Component	Quality-of-Life Component
2. Motion	0.878	
1. Pain	0.785	
3. Muscular functioning	0.738	
5. Changing directions	0.677	
16. Wellbeing: changes in my mood and/or increased frustration		0.827
13. Wellbeing: increased uncertainty, stress, pressure, and/or anxiety		0.780
15. Wellbeing: decreased overall energy		0.775
14. Wellbeing: altered relationships with team, friends, and/or colleagues		0.736
Eigenvalue	3.90	1.71
Percentage of variance	43.95	16.58
Cronbach α	0.850	0.852

Abbreviation: DPA, Disablement in the Physically Active.

^a Adapted with permission.¹⁴

^b Numbering is from the original DPA scale.

^c Items are numbered in the way in which they factored in the analyses for the results rather than the way in which they were ordered in the original DPA scale.

functional limitations constructs was high ($r = 0.86$). The correlations between the functional limitations and QOL ($r = 0.44$) and between impairment and QOL ($r = 0.44$) were acceptable. A hierarchical CFA revealed that fit indices exceeded the recommended levels ($\chi^2_{32} = 81.163$, CMIN/DF = 2.563, $P = .001$, CFI = 0.986, GFI = 0.975, TLI = 0.980, RMSEA = 0.047, IFI = 0.986). All factor loadings were significant ($P \leq .001$), and modification indices did not indicate the model fit could be significantly improved if error covariances between items were freed to covary (Figure 6). A comparison of all final model solutions for the

DPA SF-10 and SF-8 across all of the samples (2a, 2b, and 2c) did not reveal substantial differences in model fit across the fit indices (Table 11). Group mean scores on the 3 versions of the DPA scale are provided in Table 10.

Scale Correlational Results for Sample 2a

The correlation values between participant scores on the DPA scale, the DPA SF-8, and the DPA SF-10 were high. Scores on the DPA SF-8 highly correlated with the DPA scale scores at $r = 0.94$ ($P \leq .001$, $R^2 = 0.88$), whereas the scores on the DPA SF-10 correlated with those on the DPA scale at $r = 0.97$ ($P \leq .001$, $R^2 = 0.94$). The correlation between scores on the DPA SF-10 and SF-8 was also high ($r = 0.98$, $P \leq .001$, $R^2 = 0.96$).

DISCUSSION

The first purpose of our study was to examine the psychometric properties of the DPA scale by studying a larger and more diverse physically active sample. Another purpose was to use EFA to assess the structural validity of SF versions of the DPA scale and to use covariance modeling to examine whether the measurement model extracted through EFA met the fit index recommendations necessary for further validation. The final purpose was to assess the psychometric properties of the DPA SF-8 and SF-10 using a CFA approach among a large sample of physically active participants. We used contemporary psychometric analysis methods to assess the model fit of the DPA scale and SF versions.^{25–27} The participants in this study provided a more diverse, physically active pool than had previously been investigated for psychometric analysis of the DPA scale. We also used a CFA approach to more rigorously test the psychometric properties of the instruments to make a recommendation for implementation of the instruments in clinical practice and research.²⁵ Our results suggested the DPA SF-8 and SF-10 are generic PRO instruments with excellent psychometric properties for physically active populations.

Table 7. Exploratory Factor Analysis Pattern Matrix Loadings for the DPA Short Form-10^a

Item ^{b,c}	Maximum Likelihood		
	Impairment	Quality of Life	Functional Limitations
2. Motion	0.876		
1. Pain	0.781		
3. Muscular functioning	0.663		
16. Wellbeing: changes in my mood and/or increased frustration		0.831	
13. Wellbeing: increased uncertainty, stress, pressure, and/or anxiety		0.780	
15. Wellbeing: decreased overall energy		0.770	
14. Wellbeing: altered relationships with team, friends, and/or colleagues		0.727	
9. Skill: coordination, agility, precision, and balance			0.857
5. Changing directions			0.826
4. Stability			0.643
Eigenvalue	4.82	1.88	0.689
Percentage of variance	44.52	15.09	3.45
Cronbach α	0.837	0.850	0.840

Abbreviation: DPA, Disablement in the Physically Active.

^a Adapted with permission.¹⁴

^b Numbering is from the original DPA scale.

^c Items are numbered in the way in which they factored in the analyses for the results rather than the way in which they were ordered in the original DPA scale.

Table 8. Original and Revised Construct Labels for the DPA Scale Short Forms^a

Item ^{b,c}	DPA Scale Dimensions	DPA SF-8 Dimensions	DPA SF-10 Dimensions
2. Do I have impaired motion? (eg, decreased range/ease of motion, flexibility, and/or increased stiffness)	Impairments	Physical summary component	Impairments
1. Do I have pain?	Impairments	Physical summary component	Impairments
3. Do I have impaired muscle function? (eg, decreased strength, power, endurance, and/or increased fatigue)	Impairments	Physical summary component	Impairments
16. Do I have difficulties with the following. . . ? Changes in my mood and/or increased frustration	Quality of life	Quality of life	Quality of life
13. Do I have difficulties with the following. . . ? Increased uncertainty, stress, pressure, and/or anxiety	Quality of life	Quality of life	Quality of life
15. Do I have difficulties with the following. . . ? Decreased overall energy	Quality of life	Quality of life	Quality of life
14. Do I have difficulties with the following. . . ? Altered relationships with team, friends, and/or colleagues	Quality of life	Quality of life	Quality of life
9. Do I have difficulties with performing skills that are required for physical activity? (eg, coordination, agility, precision, and balance)	Functional limitations	Not included in scale	Functional limitations
5. Do I have difficulty with changing directions in activity? (eg, twisting, turning, starting/stopping, cutting, pivoting)	Functional limitations	Physical summary component	Functional limitations
4. Do I have impaired stability? (eg, the injured area feels loose, gives out, or gives way)	Impairments	Not included in scale	Functional limitations
6. Do I have difficulty with daily actions that I would normally do? (eg, walking, squatting, getting up, lifting, carrying, bending over, reaching, and going up/down stairs)	Functional limitations	Not included in scale	Not included in scale
7. Do I have difficulty maintaining the same positions for a long period of time? (eg, standing, sitting, keeping the arm overhead, or sleeping)	Functional limitations	Not included in scale	Not included in scale
8. Do I have difficulties with performing skills that are required for physical activity? (eg, running, jumping, kicking, throwing, and catching)	Functional limitations	Not included in scale	Not included in scale
10. Do I have difficulty maintaining my fitness level? (eg, conditioning, weight lifting, and cardiovascular endurance)	Disability	Not included in scale	Not included in scale
11. Do I have difficulty with participating in activities? (eg, participating in leisure activities, hobbies, and games)	Disability	Not included in scale	Not included in scale
12. Do I have difficulty with participating in activities? (eg, participating in my sport(s) of preference)	Disability	Not included in scale	Not included in scale

Abbreviations: DPA, Disablement in the Physically Active; SF, Short Form.

^a Adapted with permission.¹⁴

^b Numbering and phrasing are from the original DPA scale.

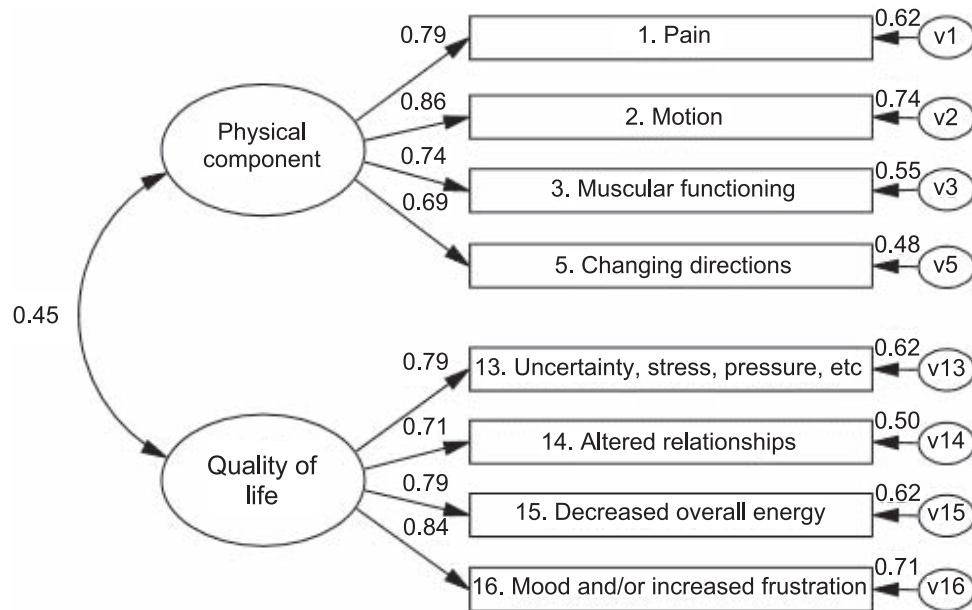
^c Items are numbered in the way in which they factored in the analyses for the results rather than the way in which they were ordered in the original DPA scale.

Confirmatory Factor Analysis of the DPA Scale

The CFA findings were similar to the results of the original study¹⁵ of the DPA scale: (1) the subdimensions of the disablement construct were highly correlated ($r \geq 0.89$), (2) model fit was improved by allowing error terms of items 8 and 12 and items 5 and 9 freedom to covary, and (3) the scale met some but not all of the strict fit indices recommendations.^{27–29,35} Although the fit indices may indicate reasonable fit, multicollinearity among the disablement subdimensions and model misspecification are concerns. Previously reported^{15,24} high Cronbach α levels (≥ 0.89) combined with the high α levels found in our study indicated potential item redundancy. The high correlation values between the latent variables in the original DPA scale analysis work (ie, ≥ 0.95)¹⁵ indicated multicollinearity, suggesting items needed to be removed from the original model.^{25,26} In this study, we found similarly high correlation values between the latent variables in addition to a standardized path coefficient >1 between the disablement and functional limitations constructs. The results make it difficult to conclude that the items for these

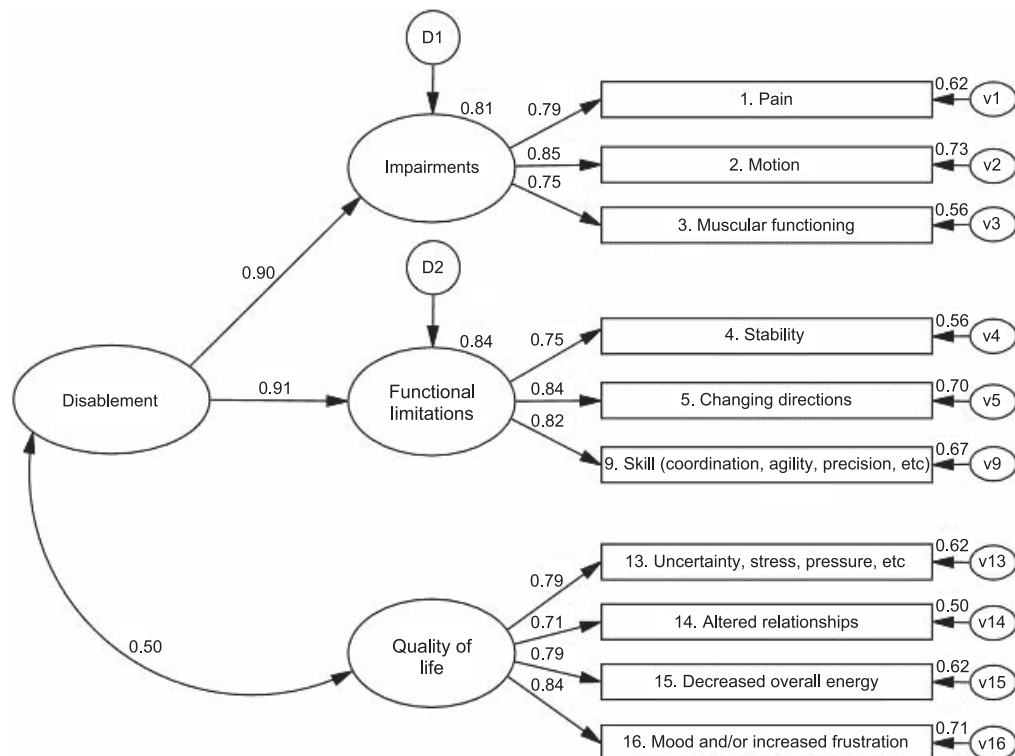
subdimensions are tapping into unique constructs.^{25,26,36} Additionally, the standardized path coefficient >1 indicates model misspecification, suggesting that the model is inadmissible despite the fit indices values that supported appropriate model fit.^{25–27}

Although it is useful to have an instrument that measures multiple constructs of disablement,^{10,11,15} the DPA scale was designed to avoid a model in which the distinction between disablement constructs was unclear.^{15,38} Our findings confirmed underlying patterns present in the previous analysis work^{15,24} on the DPA scale that indicate this was not the case. Review of all results indicated that either the originally proposed constructs were measuring much of the same phenomenon or participants were interpreting the items similarly. The high correlation and standardized path coefficient values suggested multicollinearity bordering on singularity within the disablement subdimensions for the original DPA scale model.^{25,26,36} Thus, the instrument may be improved by condensing the scale into a more concise instrument.^{25,27,36} Another option would be to reword items or provide fewer overlapping



$\chi^2 = 36.949$; degrees of freedom = 19; χ^2 to degrees of freedom ratio = 1.945; Goodness-of-fit index = 0.987; Comparative-fit index = 0.993; Tucker-Lewis index = 0.990; Bollen incremental fit index = 0.993; Root-mean-square error of approximation = 0.037; $P = .008$

Figure 3. The Disabling in the Physically Active scale 8-Item Short-Form covariance model with standardized loadings. Abbreviation: v, unique variance. Adapted with permission.¹⁵



$\chi^2 = 60.911$; degrees of freedom = 32; χ^2 to degrees of freedom ratio = 1.903; Goodness-of-fit index = 0.983; Comparative-fit index = 0.992; Tucker-Lewis index = 0.989; Bollen incremental fit index = 0.992; Root-mean-square error of approximation = 0.036; $P = .002$

Figure 4. The Disabling in the Physically Active scale 10-Item Short-Form hierarchical covariance model with standardized loadings. Abbreviation: v, unique variance. Adapted with permission.¹⁵

Table 9. Comparison of Covariance Modeling Fit Indices by Instrument and Sample 1

Scale	Sample	No. of Participants	Goodness-of-Fit Index	Comparative-Fit Index	Tucker-Lewis Index	Bollen Incremental Fit Index	Root Mean Square Error of Approximation
DPA scale	1a	690 (353 males, 330 females, 7 did not report sex; age = 23.1 ± 9.3 y)	0.929	0.957	0.947	0.957	0.069
	1b	746 (377 males, 362 females, 7 did not report sex; age = 23.15 ± 9.3 y)	0.944	0.963	0.955	0.963	0.060
	1c	796 (402 males, 386 females, 8 did not report sex; age = 23.16 ± 9.4 y)	Not calculated ^a	0.962	0.947	0.962	0.060
DPA SF-10	1a	690 (353 males, 330 females, 7 did not report sex; age = 23.1 ± 9.3 y)	0.987	0.993	0.990	0.993	0.037
	1b	746 (377 males, 362 females, 7 not reported; age = 23.15 ± 9.3 y)	0.988	0.996	0.994	0.996	0.024
	1c	796 (402 males, 386 females, 8 not reported; age = 23.16 ± 9.4 y)	Not calculated ^a	0.994	0.990	0.994	0.028
DPA SF-8	1a	690 (353 males, 330 females, 7 not reported; = 23.1 ± 9.3 y)	0.983	0.992	0.989	0.992	0.036
	1b	746 (377 males, 362 females, 7 not reported; age = 23.15 ± 9.3 y)	0.992	0.998	0.997	0.998	0.017
	1c	796 (402 males, 386 females, 8 not reported; age = 23.16 ± 9.4 y)	Not calculated ^a	0.996	0.993	0.996	0.025

Abbreviations: DPA, Disablement in the Physically Active; SF, Short Form.

^a The Goodness-of-Fit Index cannot be calculated when a sample is missing participant responses.

examples that may lead to participants not being able to distinguish between items designed to measure different constructs.³⁹ We chose to examine if more concise SF versions could be produced to resolve the model specification concerns present in the original DPA scale model.

Psychometric Analysis of the SF Versions of the DPA Scale

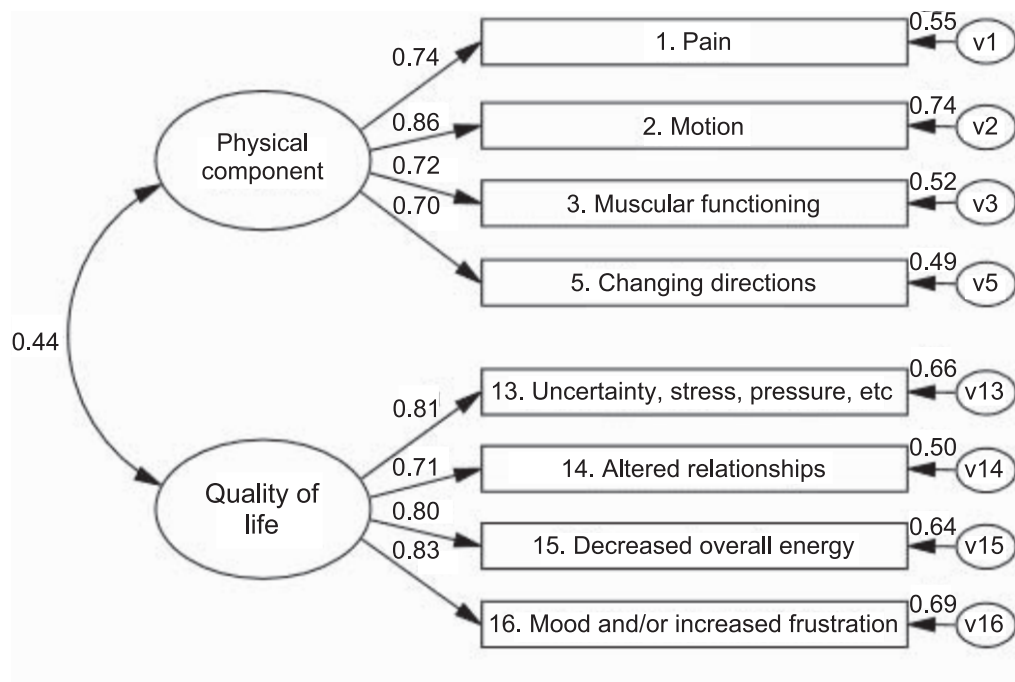
The SF versions produced from the analysis reflect the initial design of the DPA scale in that the instrument was hypothesized to measure constructs assessing physical (ie, disablement) and mental (ie, QOL) health dimensions. Our EFA findings support previous research²⁴ on the summary components of the DPA scale. However, our results also indicated further modification could improve the internal consistency of the constructs while potentially improving the scale structure (eg, reducing multicollinearity between latent variables) and reducing the response burden by creating a more concise instrument.^{25,36}

Creating a more concise model occurred primarily by removing items that had higher cross-loadings, those that did not account for a substantial portion of the variance, and those that inflated Cronbach α levels.^{25,27,36} This process led to the removal of items 6 through 8 and 10 through 12 from both SF versions. Additionally, item 4, which was originally hypothesized to address impairment, factored better in the functional limitations construct. We felt the item could be interpreted in that fashion by a patient and could theoretically fit with assessing functional limitations. These changes resulted in a mild decrease in the correlation between the functional limitations and impairment dimensions, while also resulting in the loss of all items in the proposed disability construct. However, the disability construct had a high correlation with the other subconstructs and was not supported by our EFA analysis or a previous EFA analysis.²⁴ The changes resulted in a more concise model with improved model precision as both the DPA SF-8 and SF-10 had excellent model fit, with both scales exceeding the strictest fit indices recommendations on all of the measured fit indices.^{27–29,35}

Table 10. Group Mean Scores on the DPA Scale, DPA SF-10, and DPA SF-8 in Participants With or Without Injury at Intake

Scale	Group	Sample 1		Sample 2	
		Mean ± SD	Range	Mean ± SD	Range
DPA scale	Healthy	4.92 ± 6.17	0–32	5.06 ± 7.06	0–39
	Subacute injury	26.25 ± 10.41	2–41	28.00 ± 10.05	6–52
	Acute injury	28.10 ± 11.16	3–50	28.27 ± 11.53	1–62
	Persistent injury	27.28 ± 11.94	3–55	26.65 ± 10.81	3–59
DPA SF-10	Healthy	3.34 ± 4.00	0–16	3.80 ± 4.61	0–20
	Subacute injury	14.55 ± 6.22	2–32	15.61 ± 6.14	6–31
	Acute injury	15.76 ± 6.44	1–31	16.14 ± 6.90	1–38
	Persistent injury	15.31 ± 7.11	2–34	15.09 ± 6.60	1–36
DPA SF-8	Healthy	2.90 ± 3.40	0–12	3.24 ± 3.81	0–13
	Subacute injury	11.24 ± 5.05	0–28	12.10 ± 4.74	5–25
	Acute injury	12.13 ± 5.10	0–26	12.42 ± 5.28	1–32
	Persistent injury	11.91 ± 5.56	1–27	12.03 ± 5.22	1–28

Abbreviations: DPA, Disablement in the Physically Active; SF, Short Form.

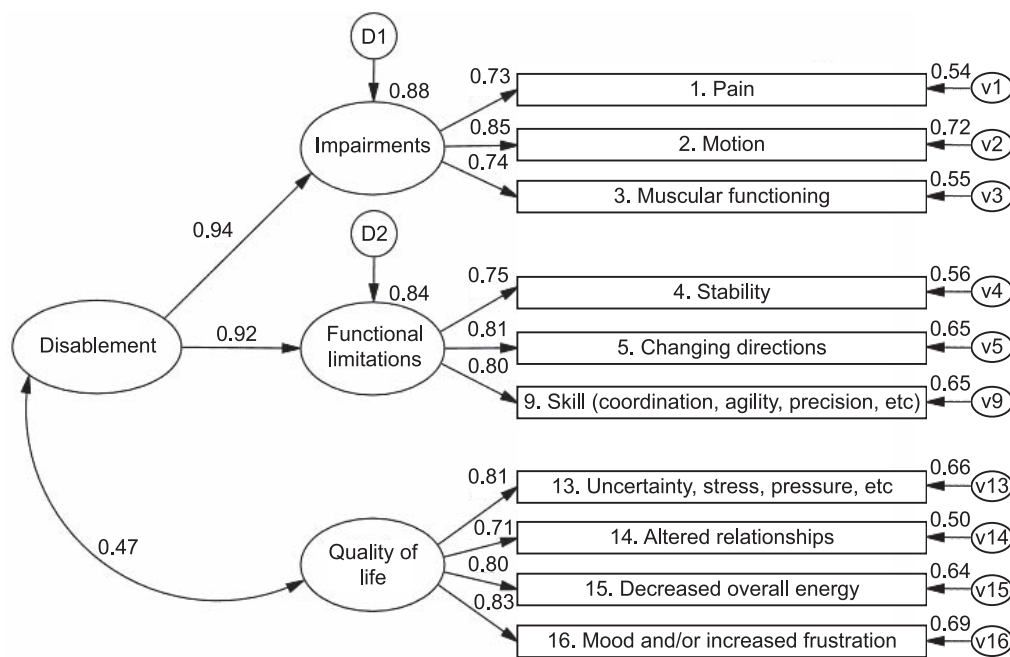


$\chi^2 = 29.459$; degrees of freedom = 19; χ^2 to degrees of freedom ratio = 1.550; Goodness-of-fit index = 0.989; Comparative-fit index = 0.996; Tucker-Lewis index = 0.994; Bollen incremental fit index = 0.996; Root-mean-square error of approximation = 0.028; $P = .059$

Figure 5. The Disabling in the Physically Active scale Short Form-8 confirmatory factor analysis measurement model with standardized loadings. Abbreviation: v, unique variance. Adapted with permission.¹⁵

The CFA of the DPA SF-8 indicated the model was an acceptable approximation of the data, and the overall model fit exceeded the fit indices recommendations.^{27–29,35} The DPA SF-8 narrowed the breadth of the information

collected by the DPA scale. However, the correlation value ($r = 0.94$, $R^2 = 0.88$) suggested the 8-item version accounted for an acceptable amount of variance in participant responses on the original DPA scale when



$\chi^2 = 81.163$; degrees of freedom = 32; χ^2 to degrees of freedom ratio = 2.536; Goodness-of-fit index = 0.975; Comparative-fit index = 0.986; Tucker-Lewis index = 0.980; Bollen incremental fit index = 0.986; Root-mean-square error of approximation = 0.047; $P < .001$

Figure 6. The Disabling in the Physically Active scale Short Form-10 hierarchical confirmatory factor analysis measurement model with standardized loadings. Abbreviation: v, unique variance. Adapted with permission.¹⁵

Table 11. Comparison of Confirmatory Factor Analysis Fit Indices Across Sample 2

Short Form	Sample	No. of Participants	Goodness-of-Fit Index	Comparative-Fit Index	Tucker-Lewis Index	Bollen Incremental Fit Index	Root Mean Square Error of Approximation
Disablement in the Physically Active Short Form-10	1a	690 (351 males, 337 females, 2 did not report sex; age = 22.9 ± 9.3 y)	0.975	0.986	0.980	0.986	0.047
	1b	746 (375 males, 369 females, 2 did not report sex; age = 23.1 ± 9.6 y)	0.973	0.980	0.971	0.980	0.053
	1c	796 (400 males, 393 females, 3 did not report sex; age = 23.1 ± 9.6 y)	Not calculated ^a	0.981	0.968	0.982	0.050
Disablement in the Physically Active Short Form-8	1a	690 (351 males, 337 females, 2 did not report sex; age = 22.9 ± 9.3 y)	0.989	0.996	0.994	0.996	0.028
	1b	746 (375 males, 369 females, 2 did not report sex; age = 23.1 ± 9.6 y)	0.992	0.997	0.996	0.997	0.021
	1c	796 (400 males, 393 females, 3 did not report sex; age = 23.1 ± 9.6 y)	Not calculated ^a	0.997	0.994	0.997	0.023

^a The Goodness-of-Fit Index cannot be calculated when a sample is missing participant responses.

comparing cumulative scores, while also improving the precision of the instrument given the model fit. Furthermore, the DPA SF-8 allows for the collection of summative dimension scores for physical and mental health statuses as unique constructs. Because it has been argued that QOL and disablement are unique constructs,^{15,17,20–22} it is important to be able to score the constructs separately to determine a patient's health status and help guide decisions in clinical care to match interventions to the specific dimensional impairment a patient is experiencing.²⁴

The DPA SF-10 also demonstrated model fit that exceeded the strictest recommendations.^{27–29,35} This version of the instrument more closely resembled the original design of the DPA scale,¹⁵ maintaining a unique QOL construct and a second-order disablement construct, but the disablement construct now contained only 2 subdimensions (ie, impairment and functional limitations) with improved measurement precision. The cumulative scores on the DPA SF-10 also maintained a high correlation ($r = 0.97$, $R^2 = 0.94$) with scores on the DPA scale, indicating the vast majority of the variance in participant responses in the DPA scale total scores were also accounted for in this SF version. The DPA SF-10 also allows for the scoring of the dimensions (ie, disablement and QOL) as unique constructs. This is valuable because the scores can provide greater insight into the patient's experience while potentially reducing the response burden for a patient and barriers to implementation for the clinician.^{5,24}

The DPA SF-8 and SF-10 accomplished the following: (1) accounted for more than 88% of the variance in participant scores on the original DPA scale in this sample, (2) improved the scale structure and model fit, (3) provided summary components that can be scored as unique constructs, and (4) demonstrated a more concise scale with a reduced response burden on patients that may lead to more efficient self-administration.^{25,30,36} The DPA SF-8 also addressed the topic of high correlations between the subdimensions of the higher-order construct disability, thereby resolving the potential multicollinearity in the proposed model. Both SF versions addressed the redundancy of items measuring the constructs based on improved internal consistency values.³⁶

The summary components created in the DPA SF-10 and SF-8 provide additional benefits to practitioners. The new versions offer feasible and efficient tools for measuring important health-related constructs among the physically active by calculating scores for the summary dimensions,²⁴ which may relieve the burden on clinicians who feel it is difficult using multiple instruments^{5,40,41} or that instruments take too long to complete.^{42,43} The new versions allow clinicians to measure physical status using either a 1- or 2-dimensional instrument while simultaneously assessing QOL as a unique construct. The concise scales have the potential to reduce barriers to practice implementation.

Implementation in Clinical Practice and Research

The appropriate choice between the SF versions may depend on the end goal of the instrument user. Researchers^{10,11,14,15} have argued that measuring complex constructs, such as health status or disablement, requires an instrument designed to measure the multiple subconstructs that comprise the higher-order construct. However, it can also be argued that the subconstructs should be unique dimensions without substantial overlap to provide a more concise and psychometrically sound instrument, as well as the most precise measures for clinical practice and research.^{25,26}

The DPA SF-10 improves the precision of the original instrument, as demonstrated by excellent measurement fit and reduced correlation values between the latent variables. However, this version does not fully resolve the potential multicollinearity of the disablement construct.^{25,26} The DPA SF-8 resolves these concerns while providing improved model fit. Yet the DPA SF-8 does not account for as much variance in DPA scale responses as the DPA SF-10 does. Both instruments offer the opportunity to score individual constructs²⁴ and measure QOL as a unique component of the injury process that is not traditionally captured by the dimensions designed to assess physical health status.^{15,21} Both instruments have measurement properties indicating the scales are valid measures of these constructs in physically active populations, which has not been the case with other instruments, such as the SF-36.¹⁸ The reduced length and increased precision of the SF

Disablement in the Physically Active Scale Short Form-8

Instructions: Please answer **each statement** with one response by shading in the circle that most closely describes your problem(s) within the past **24 hours**. Each problem has possible descriptors under each. Not all descriptors may apply to you but are given as common examples.

KEY

- 1 – No problem
- 2 – I have the problem(s), but it does not affect me
- 3 – The problem(s) slightly affects me
- 4 – The problem(s) moderately affects me
- 5 – The problem(s) severely affects me

	No problem	Does not affect	Slight	Moderate	Severe
Physical Summary Component	1	2	3	4	5
Pain – “Do I have <i>pain</i> ?”	O	O	O	O	O
Motion – “Do I have <i>impaired motion</i> ?” Ex. decreased range/ease of motion, flexibility, and/or increased stiffness	O	O	O	O	O
Muscular Functioning – “Do I have <i>impaired muscle function</i> ?” Ex. decreased strength, power, endurance, and/or increased fatigue	O	O	O	O	O
Changing Directions – “Do I have <i>difficulty with changing directions in activity</i> ?” Ex. twisting, turning, starting/stopping, cutting, pivoting	O	O	O	O	O
<i>Physical summary score (total score – 4)</i>	_____ / 16				
Quality-of-Life Component	1	2	3	4	5
Well Being – “Do I have <i>difficulties with the following...</i> ?”	O	O	O	O	O
1) Increased uncertainty, stress, pressure, and/or anxiety	O	O	O	O	O
2) Altered relationships with team, friends, and/or colleagues	O	O	O	O	O
3) Decreased overall energy	O	O	O	O	O
4) Changes in my mood and/or increased frustration	O	O	O	O	O
<i>Quality-of-Life score (total score – 4)</i>	_____ / 16				

Figure 7. The Disablement in the Physically Active Short Form-8. Adapted with permission.¹⁴

versions of the DPA scale may remove barriers for clinicians and patients to use the instrument efficiently in practice.^{5,40–43} Although an argument can be made for using either SF version, our recommendation would be to use the DPA SF-8 due to its improved model fit, instrument precision, and reduced response burden.

Instrument Scoring

Scoring the DPA SF-8 (Figure 7) or SF-10 (Figure 8) follows a similar procedure to that for the original DPA scale (ie, sum of values for all items in a dimension minus the number of items used to measure that dimension). The original DPA scale was scored using a cumulative disablement score by summing a patient’s scores on all of the items.¹⁵ We would argue against a cumulative summary score because a summary score of 2 unique constructs should not be assumed to provide an accurate portrayal of health status when health status is defined as one of the already existing dimension names (ie, disablement).^{15,20–22} The results of our study, along with previous findings,^{15,24} suggest that the QOL and disablement constructs are

unique. In short, the 2 constructs are not measuring the same phenomenon and responses should not be summed for a disablement score. It may be more effective and more in line with psychometric analyses of the scales to use summative scores for each individual construct (eg, a score for disablement and a score for QOL) versus a cumulative score. Examining the individual construct scores likely provides a better and more accurate portrayal of a patient’s health status as it relates to using these scales to measure the proposed constructs.²⁴

LIMITATIONS

Our study was conducted on the largest and most diverse sample (eg, included adolescent athletes, national sample, noncompetitive athletes) for examining the DPA scale to date, but it did have limitations. We selected a cross-sectional sample without long-term follow-up or comparison with a criterion standard scale. Thus, we did not establish the responsiveness (eg, minimal clinically important difference values) or test-retest reliability of the SF versions of the scale. Further, we were unable to exhaust all

Disablement in the Physically Active Scale Short Form-10

Instructions: Please answer **each statement** with one response by shading in the circle that most closely describes your problem(s) within the past **24 hours**. Each problem has possible descriptors under each. Not all descriptors may apply to you but are given as common examples.

KEY

- 1 – No problem
- 2 – I have the problem(s), but it does not affect me
- 3 – The problem(s) slightly affects me
- 4 – The problem(s) moderately affects me
- 5 – The problem(s) severely affects me

	No problem	Does not affect	Slight	Moderate	Severe
Impairments Summary Component	1	2	3	4	5
Pain – “Do I have <i>pain</i> ?”	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Motion – “Do I have <i>impaired motion</i> ?” Ex. decreased range/ease of motion, flexibility, and/or increased stiffness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Muscular Functioning – “Do I have <i>impaired muscle function</i> ?” Ex. decreased strength, power, endurance, and/or increased fatigue	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Impairments summary score (total score – 3)</i>	_____ / 12				
Functional Limitations Summary Component	1	2	3	4	5
Stability – “Do I have <i>impaired stability</i> ?” Ex. the injured area feels loose, gives out, or gives way	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Changing Directions – “Do I have <i>difficulty with changing directions</i> in activity?” Ex. twisting, turning, starting/stopping, cutting, pivoting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Skill Performance – “Do I have <i>difficulties with performing skills</i> that are required for physical activity?” Ex. twisting, turning, starting/stopping, cutting, pivoting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Functional Limitations summary score (total score – 3)</i>	_____ / 12				
Quality-of-Life Summary Component	1	2	3	4	5
Well Being – “Do I have <i>difficulties with the following...</i> ?”	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1) Increased uncertainty, stress, pressure, and/or anxiety	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2) Altered relationships with team, friends, and/or colleagues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3) Decreased overall energy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4) Changes in my mood and/or increased frustration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Quality-of-Life summary score (total score – 4)</i>	_____ / 16				

Figure 8. The Disablement in the Physically Active Short Form-10. Adapted with permission.¹⁴

the analyses necessary to completely establish the reliability or validity of the SF versions of the DPA scale.

Our methods are common for instrument design procedures (eg, calibration and validation samples from 1 data collection), yet respondents may have been influenced by items that were not included in the final models when they were asked to complete the full DPA scale. Additionally, although physically active participants from the child/adolescent and geriatric demographics were included in our sample, the majority of the sample was between the ages of 18 and 25 years. The items may not be well suited for members of these demographic groups for various reasons, such as item readability or a task (eg, cutting) not being

appropriate for a patient in these groups. Thus, it would be valuable to study the SF versions further in these groups to ensure that the items are not biased.

Therefore, future researchers must assess the validity of the SF versions, including performing invariance testing. Invariance testing of the instruments would allow conclusions to be drawn about the extent to which items are interpreted similarly across groups (eg, males and females, age groups, injury types), which is a necessary prerequisite for using the scale to assess group differences. Also, further study should be done to compare the summary components of the scale with other commonly used instruments (eg, patient-specific functional scale) to determine if the

summary component scores can be used to replace other instruments, which would further reduce barriers to implementation among patients and clinicians. Finally, the summary components of the DPA SF-8 and SF-10 need to be compared with other scales (eg, numeric pain rating scale, patient-specific functional scale) to determine the validity of the summary dimensions.

CONCLUSIONS

A CFA of the original DPA scale resulted in similar findings as the original assessment of the instrument, indicating the need for scale modification. Initial examination demonstrated the DPA SF-8 and SF-10 were plausible alternatives to the DPA scale. The original scale item pool was reduced by approximately 40% to 50%, but the SFs still accounted for a substantial portion of the variance in participant responses on the DPA scale. The CFAs of the DPA SF-8 and SF-10 confirmed that the shortened versions were psychometrically sound alternatives to the DPA scale. The new versions account for a substantial portion of the variance in participant cumulative scores on the DPA scale while providing improved scale structure and measurement precision. The SF versions improved measurement properties and may result in more efficient clinical use because they reduce burdens for both patients and clinicians. Further study is still needed to establish the responsiveness of the scale and determine measurement invariance and construct validity in research and practice.

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