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**Research Article**

# Development and Item Analysis of A Multidimensional Scale to Measure Muscle Strengthening Activity Behavior: The Muscle Strengthening Activity Scale (MSAS).

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**Abstract:** **Background**: The health benefits of muscle strengthening activity (MSA) include the improvement of bone health, body composition, muscular strength, physical function, as well as reduced risk for many chronic diseases and improved health-related quality of life (HRQOL). However, the types of MSA associated with these benefits are less understood. This study reports the development and item analysis of a multidimensional scale to measure MSA behavior. **Methods**: The following procedures were followed in this measurement study: (1) formation of conceptual definitions for MSA and its subdomains through literature review and collaboration with content experts, (2) development of a large set of MSA items for each subdomain, (3) pilot testing items to a focus group with collected feedback, (4) pilot testing items for a pilot item analysis, (5) administration of an initial MSA instrument to a large sample of participants, (6) formal reliability and item analyses, and 7) formation and naming of a developed instrument. **Results**: The MSA instrument was initially defined to have two subdomains: muscular strength and muscular endurance. A 20-item scale was reduced to an 8-item scale through initial item analysis and focus group feedback. A convenience sample of 400 adult MSA participants completed the 8-item scale via electronic survey methods. Formal reliability and item analyses indicated that 7 items could measure three MSA subscales: muscular *strength* behavior, muscular *endurance* behavior, and *body* weight exercise behavior. Two additional items are included in the newly developed scale to quantify MSA participation. **Conclusion**: The seven-item MSA scale (MSAS) may be a simple and valid tool for measuring MSA in adults.

**Keywords:** Muscle strengthening activity (MSA), Scale development, Reliability, Item analysis.

## INTRODUCTION

The new 2018 Physical Activity Guidelines for Americans (2nd edition) states that adults should participate in muscle strengthening activities of at least moderate intensity using all major muscle groups on two or more days a week (U.S. Department of Health and Human Services. 2018). This guideline is supported by an abundance of research showing positive relationships between muscle strengthening activity (MSA) and health outcomes in generally healthy adult populations. Research studies using various forms of resistance training as an intervention have consistently shown improvement in muscular strength (Englund, D. A. *et al.,* 2018; Mann, S. *et al.,* 2018), muscle mass (Vikberg, S. *et al.,* 2019; Tsuzuku, S. *et al.,* 2018), and bone health (Mathis, S.L., & Caputo, J.L. (2018;

Huovinen, V. *et al.,* 2016), in groups receiving a resistance training protocol. Additionally, research indicates a beneficial relationship between MSA and many different health problems, such as coronary heart disease risk factors (Cottell, K. E. *et al.,* 2011; Vincent, K. R. *et al.,* 2003), cancer mortality (Kamada, M. *et al.,* 2017), diabetes (Shiroma, E. J. *et al.,* 2017), metabolic syndrome (Tomeleri, C. M. *et al.,* 2018), as well as all-cause mortality (Loprinzi, P.D. *et al.,* 2017; Kraschnewski, J. L. *et al.,* 2016). The benefits of MSA also extend to other facets of health-status, such as mental health, perceived health, and health-related quality of life (HRQOL) (Sayer, A. A. *et al.,* 2018; McDowell, C.P. *et al.,* 2018).

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The scientific literature, however, does not show conclusive evidence regarding MSA training behavior and associated health outcomes. This gap in the literature is likely responsible for current MSA guidelines neglecting specific training variables such as intensity and volume, leaving participants unsure of MSA programming goals. Moreover, even the once conventional programming principles involving muscular strength training (higher loads with lower repetitions) versus muscular endurance training (lower loads with higher repetitions) for improving muscle strength and hypertrophy, respectively, have recently been under scrutiny (Schoenfeld, B.J. *et al.,* 2017). This ambiguity highlights the need for an assessment tool that can measure the training behavior associated with MSA for use in applied health research and interventions. In this context, MSA behavior can be considered an attribute of an individual such as their beliefs, expectations, and motives related to MSA (Glanz, K. *et al.,* 2015). Additionally, measured levels of a behavioral attribute, such as MSA behavior, generally vary across individuals, with those measuring high on an attribute likely to possess more of that behavior than someone measuring low on that attribute (Morrow, J.r. *et al.,* 2015). Therefore, it serves to reason, that MSA behavior can be measured as an attribute by constructing scores from a set of test items that are related to each other and support the construct (Kline, T. 2015).

Plenty of research has been conducted in which health behaviors have been conceptualized as attributes possessed by individuals. For example, one study used four test items from a school-based physical activity and nutrition questionnaire to validate a latent variable measuring healthy food consumption in third-grade children (Larsen, A.L. *et al.,* 2015). Results from this research indicated that the four items (fruit, vegetables, and milk & fruit juice) had good fit to a single factor model and remained stable across time and gender. Several other studies have used scales administered to individuals to measure underlying attributes of behavior, such as physical activity (Pate, R.R. *et al.,* 2018; Wang, J. J. *et al.,* 2017), sedentary behavior (Silva, D.A. *et al.,* 2018; Tucker, C. A. *et al.,* 2014), and diet (Ghisi, G. L. D. M. *et al.,* 2019).

Despite ample research utilizing scales to measure health-related behavioral constructs, no such research attempts to measure MSA as an underlying behavioral attribute. Therefore, the training behavior associated with an individual's MSA can be conceptualized as an attribute that requires a valid form of assessment. The purpose of this measurement study was to develop a multidimensional scale to measure MSA behavior. Additionally, this study performed an item analysis on a newly developed MSA instrument.

## METHODS
### Study procedures
This measurement study followed seven steps in the development of its instrument. **First**, definitions of MSA and its subdomains were conceptualized through literature review and collaboration with content experts. **Second**, a large pool of scale items was developed for each subdomain. It was decided that more items were to be developed than were likely needed. Additionally, items were developed to try and cover a broad range of MSA attributes (i.e., less serious MSA participants to very serious MSA participants). **Third**, an initial MSA instrument was developed and administered to a mid-sized focus group of highly trained MSA participants. Feedback from the focus group was collected regarding the interpretation and readability of items as well as opinions regarding each item's ability to target the MSA subdomains. **Fourth**, after modifying the MSA instrument based on focus group results, the scale was pilot tested to a small group of college students. Space on the instrument was available for subjective feedback similar to the previous focus group stage. A pilot item analysis was then conducted to further evaluate the instrument and review the functioning of the rating scale categories. **Fifth**, after modifying the MSA instrument according to pilot test results, the new scale was administered to a large sample of adults. **Sixth**, formal reliability and item analyses were performed. And **seventh**, a final newly developed scale was created with a plan for scale scoring.

### Scale development
MSA was conceptually defined in this study as intentional physical activity (i.e., exercise) that would use large muscle groups to maintain or increase one's muscular strength and/or muscular endurance and would include activities such as push-ups, sit-ups, yoga, and weight lifting. MSA was further considered to have two subdomains: muscular strength and muscular endurance. Therefore, the MSA instrument was developed to produce two different scale scores reflecting each subdomain. Items were constructed independently for each subdomain. A pool of ten items for each subdomain was finalized and an initial MSA instrument was developed with twenty items. A seven-category rating scale was used for all items and ranged from "*Never true*" to "*Always true*". Items consisted of personalized statements regarding both muscular strength training behavior and muscular endurance training behavior. For example, "*I often exercise my muscles with heavy weight that I can lift 1 to 8 times*". After results from the focus group stage and the pilot item analysis stage, the MSA instrument was reduced to eight items with a rating scale of five categories of the same range. A screener question was included at the top of the instrument to ask individuals if they regularly participate in MSA. Those responding "*No*" are instructed to not continue to the rest of the instrument. A second part of the instrument contained two items

asking participants about their frequency and duration of MSA participation. These items were included to quantify amounts of MSA performed, however, these items were not evaluated in this study.

### Statistical analyses

The statistical analysis plan described relates to the formal item analysis that was conducted on the eight-item MSA instrument. The statistical analysis plan contained six steps. **First**, internal consistency reliability analysis, using Cronbach's alpha and item-total correlations, was performed on both MSA subdomains. Alpha values were inspected to validate an item's association with each subdomain. Since the purpose of this study was to develop a new scale, alpha values approaching 0.70 were considered optimal (Nunnally, J. C. 1978). However, it was also understood at study onset that alpha values may be lower because of the exploratory nature of the study and the small number of scale items in each subdomain. Therefore, values above 0.60 would also be considered acceptable

(Hair, J. F. et al., 2010). Similarly, item-total correlations above 0.20 (corrected) and 0.50 (uncorrected) were also considered satisfactory (Hair, J. F. et al., 2010; Kline, P. 2015). **Second**, the reliability analysis was repeated to account for any modifications to the scale based on the previous step. **Third**, rating scale category function was examined by computing endorsement percentages. Assessment of this step was simply to inspect if each item category was useful while considering the fact that all respondents were in fact active MSA participants (i.e., endorsement of the "Never true" category may not be common). **Fourth**, item difficulty was examined by computing item means and standard deviations. **Fifth**, item discrimination was evaluated by reporting correlations between item responses and subscale scores of the same and different subscale as the item. **Sixth**, descriptive statistics were computed on all subscale scores. All analyses were performed using SAS version 9.4 (Cody, R. P., & Smith, J. K. 2006).

## RESULTS

**Table 1. Initial Internal consistency reliability of the MSA instrument subdomains (*N*=400).**

| | Endurance | | | Strength | |
|---|---|---|---|---|---|
| Item | $r_{total}$ | $\alpha_{deleted}$ | Item | $r_{total}$ | $\alpha_{deleted}$ |
| I4 | .270 | **.635** | I1 | .372 | .356 |
| I6 | .433 | .518 | I2 | .372 | .356 |
| I7 | .471 | .489 | I3 | .059 | **.625** |
| I8 | .419 | .529 | I5 | .410 | .319 |
| Overall α | | .616 | Overall α | | .501 |

Note. $r_{total}$ is corrected item correlation with total subscale score. $\alpha_{deleted}$ is Cronbach alpha with that item deleted from the subscale. Bold values indicate preferred reliability.

**Table 2. Final Internal consistency reliability of the MSA instrument subdomains (N=400).**

| | Endurance | | | Strength | |
|---|---|---|---|---|---|
| Item | $r_{total}$ | $\alpha_{deleted}$ | Item | $r_{total}$ | $\alpha_{deleted}$ |
| I6 | .434 | .553 | I1 | .505 | .423 |
| I7 | .496 | .464 | I2 | .395 | .579 |
| I8 | .406 | .591 | I5 | .404 | .567 |
| Overall α | | .635 | Overall α | | .625 |

Note. $r_{total}$ is corrected item correlation with total subscale score. $\alpha_{deleted}$ is Cronbach alpha with that item deleted from the subscale.

A total of N=1,240 adults agreed to take the MSA instrument. Of which, N=400 adults indicated participating in regular MSA. Table 1 contains results for the initial reliability analysis on both subscales. The muscular endurance scale reliability was adequate (α=.62). However, the endurance scale reliability could be improved if item #4 was removed. Similarly, item #4 corrected item-total correlation was low ($r_{total}$=.27) in comparison to other scale corrected item-total correlations. The muscular strength scale reliability was moderate (α=.50). However, the strength scale reliability could be improved if item #3 was removed. Likewise, item #3 corrected item-total correlation was low ($r_{total}$=.06). Table 2 contains results for the follow-

up reliability analysis on both subdomains after removing the inconsistent items. The muscular endurance scale reliability was adequate (α=.64), with no other items showing inconsistency with the scale. The muscular strength scale reliability was also adequate (α=.63), with no other items showing inconsistency with its scale. Given these results, each subdomain included three items, for a total of six items in the MSA instrument. However, after further inspection of item #4, it was concluded that it was measuring a third construct not initially conceptualized. Therefore, it was decided to allow item #4 to remain in the scale, but to consider it a single-item measuring body weight exercise. This decision will be confirmed

in the next series of analyses. Given these results, the newly developed MSA instrument is to be considered a three-dimensional scale with a total of seven items, henceforward called the MSA scale (MSAS).

**Table 3. Item analysis for the 7-item MSA scale (MSAS), *N*=400.**

| Item | Never True | Rarely True | Sometimes True | Usually True | Always True | *Mean* | *SD* | $r_{Strength}$ | $r_{Endurance}$ |
|---|---|---|---|---|---|---|---|---|---|
| Q1: Strength | 11.0 | 16.8 | 25.0 | 21.5 | 25.8 | 3.3 | 1.3 | .832 | .105 |
| Q2: Strength | 12.3 | 27.0 | 35.5 | 17.8 | 7.5 | 2.8 | 1.1 | .727 | .009 |
| Q3: Strength | 1.3 | 8.0 | 18.0 | 35.8 | 37.0 | 4.0 | 1.0 | .703 | .296 |
| Q4: Endurance | 5.8 | 20.3 | 38.0 | 22.8 | 13.3 | 3.2 | 1.1 | .101 | .773 |
| Q5: Endurance | 3.3 | 13.0 | 28.3 | 37.5 | 18.0 | 3.5 | 1.0 | .184 | .794 |
| Q6: Endurance | 1.8 | 10.5 | 33.3 | 39.3 | 15.3 | 3.6 | 0.9 | .104 | .713 |
| Q7: Body | 8.5 | 23.0 | 30.0 | 25.3 | 13.3 | 3.1 | 1.2 | -.144 | .269 |

*Note.* Rating scale values are percentages (%). Scoring: Never true =1, Rarely true = 2, Sometimes true = 3, Usually true = 4, and Always true = 5. $r_{strength}$ is item correlation with the strength scale score. $r_{endurance}$ is item correlation with endurance scale score.

Table 3 contains results from the item analysis of the seven-item MSAS. The distributions of item endorsements were adequate for scale development. The lower attribute category of "*Never true*" had the fewest number of endorsements, as compared to other rating scale categories. However, since all item statements represented MSA, and all respondents reported regular MSA participation, it stands to reason this category would receive fewer endorsements than the others. Item difficulty values were also as expected considering the MSA participation of the respondents. Mean (SD) values ranged from 2.8 (1.1) to 4.0 (1.0). Finally, item-total correlations were as expected, indicating adequate item discrimination. All three strength scale items showed strong association ($rs_{strength} > .703$) with the strength scale score. Conversely, all three strength items showed poor association ($rs_{endurance} < .296$) with the endurance scale score. Similarly, all three endurance scale items showed strong association ($rs_{endurance} > .713$) with the endurance scale score. With all three endurance items showing poor association ($rs_{strength} < .184$) with the strength scale score. Finally, as anticipated, the body weight exercise item showed weak association with both the strength score ($r_{strength} = -.144$) and endurance score ($r_{endurance} = .269$), indicating that it is measuring a construct different from both muscular endurance and muscular strength.

**Table 4. Descriptive statistics for the 7-item MSAS scores (*N*=400).**

| Scale | *Mean* | *Median* | *SD* | *Min* | *Max* |
|---|---|---|---|---|---|
| Strength | 10.1 | 10.0 | 2.6 | 3 | 15 |
| Endurance | 10.3 | 10.0 | 2.3 | 3 | 15 |
| Body | 3.1 | 3.0 | 1.2 | 1 | 5 |

*Note.* SD is standard deviation. Min is minimum value. Max is maximum value. All scale scores are derived by summing their respective response category values. Muscular strength behavior scores can range from 3 to 15. Muscular endurance behavior scores can range from 3 to 15. Body weight exercise behavior scores can range from 1 to 5.

Table 4 contains summary data for the three MSAS scores, henceforward called *strength*, *endurance*, and *body*. All MSAS scores can be derived by summing their respective response category values. Since the muscular *strength* behavior subscale uses three items (ranging from 1 to 5), *strength* scores can range from 3 to 15. Similarly, since the muscular *endurance* behavior subscale uses three items, *endurance* scores also can range from 3 to 15. The *body* weight exercise behavior subscale uses only a single item and so *body* scores can range from 1 to 5. Larger values across all three MSAS scores represent greater respective MSA attribute. For example, an MSA participant receiving a *strength* score of 13 would possess a greater tendency to train their muscles for muscular strength and greater tendency to expect to receive positive muscular strength benefits as compared to another participant with a *strength* score of 8. Descriptive statistics on these scale scores were similar, with a mean (SD) *strength* score of 10.1 (2.6) and mean (SD) *endurance* score of 10.3 (2.3). The *body* scores had a mean (SD) of 3.1 (1.2). These summary statistics are once again as expected given the MSA participation of the respondents.

**DISCUSSION**
The purpose of this study was to develop a relatively brief survey instrument to measure the training behavior associated with MSA. Using content validation methods, an initial instrument of 20 items representing two subscales was developed. After focus group assessment, pilot testing, and formal reliability and item analyses, the MSAS was developed with a total of seven items and three subscales: *strength*, *endurance*, and *body*. Results from the item-analysis indicated that the MSAS is a reliable instrument for measuring three different MSA constructs. That is, both *strength* and *endurance* scales showed acceptable

internal consistency reliability for development stages on scales with as few items as three (Nunnally, J.C., & Bernstein, I.H. 1994; Tavakol, M., & Dennick, R. 2011). Additionally, the correlations between the subscale scores and their own scale items were strong, whereas the correlations between subscale scores and their opposing scale items were weak, indicating scale items could discriminate across constructs reliably (McDonald, R.P. 2013). Given these results, this study provides content validity and internal consistency reliability evidence for the MSAS. Furthermore, since reliability is a condition of validity, this study additionally provides necessary empirical evidence for the validation of the MSAS (Gillespie, D.F., & Perron, B.E. 2015).

The development and validation of the MSAS will have vast implications for both population level and intervention-based research. As previous mentioned, research relating MSA behavior (*strength*, *endurance*, and *body*) to health outcomes is sparse to nonexistent. In contrast, in the physical activity literature, much research has been conducted on varying types of physical activity behavior and related outcomes. A recent study made an examination of the association between specific types of physical activity (walking, household activity, sport, and exercise) and mortality, both all-cause and cardiovascular disease specific (Cheng, S. W. M. *et al.,* 2018). Another study examined the contribution of specific types of physical activity (walking, gardening, cycling, and household) on life expectancy (Dhana, K. *et al.,* 2016). Other studies have assessed different types of physical activity to examine their association with bone mineral density, coronary heart disease, cancer, obesity, metabolic syndrome, mental distress, depression, and HRQOL (Koolhaas, C. M. *et al.,* 2016; Sciamanna, C. N. *et al.,* 2017). Once again, the MSA literature has yet to make such research attempts. Therefore, given the development of the MSAS, research relating MSA to health outcomes will be scientifically plausible.

Although this measurement study is a positive step toward increasing research related to MSA, more psychometric evidence is needed before its widespread use. Three additional phases (possibly studies) are currently planned to further validate the MSAS. These measurement phases include the examination of MSAS 1) construct validity, 2) reliability, and 3) predictive validity. To assess construct validity of the MSAS, both conventional (exploratory and confirmatory factor analyses) and modern measurement (item response theory) models may be employed (Memari, A.H. 2016). To assess the reliability of MSAS scores, both a stability (test-retest) study and generalizability (Pate, R.R. *et al.,* 2018; G-theory) study may be utilized (Rech, C.R. *et al.,* 2011; Barreira, T.V. *et al.,* 2015). Finally, to further assess the validity of MSAS scores, an experimental approach where MSAS scores are regressed on groups with known differences in MSA

behavior may be exercised (Hofman, C.S. *et al.,* 2017). Additionally, the current study was fortunate to not be faced with missing data from respondents. Moreover, instructions for scoring the MSAS involve summing across scale item responses. This scoring procedure does not account for missing responses. Therefore, future considerations should be placed on scoring rules when missing data are encountered, such as using scale means over summing or using a no score rule for missing data (as examples).

## CONCLUSIONS

This study explained the development of a new scale that can assess MSA behavior in adults. The newly developed MSAS includes seven scale items and will yield three MSA scores: muscular *strength* behavior, muscular *endurance* behavior, and *body* weight exercise behavior. The MSAS was developed to be used for fitness assessments, descriptive research, and health-related clinical trials. The MSAS may be a simple and valid tool for measuring MSA in adults.

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