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Systematic Review
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Assessment of Muscle Strength in Para Sport Athletes: A Systematic Review

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ABSTRACT

Background: Accurate and reliable muscle strength assessment is essential for monitoring injury risk, monitoring the effectiveness of rehabilitation or strength training programs, and for sport classification purposes. This study aims to look at measurement tools to assess muscle strength in para-athletes, look at the characteristics of muscle strength assessment methods, and determine the validity and reliability of several muscle strength measurement tools.

Subjects and Method: This systematic review used methods described in the Cochrane Handbook for Systematic Reviews of Interventions and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Data searches in several databases (PubMed, Scopus, and Google Scholar) were conducted using the boolean search method. The keywords used in the literature search were "muscle strength" OR "muscle power" AND "assessment" OR "outcomes" AND "isometric contraction" OR "isotonic contraction" AND "para-sports" OR "para-athletics" AND "paralympic".

Results: Isometric strength testing was shown to be valid and reliable (ICC ≥ 0.85) but limited to static measurements; isokinetic testing was shown to be valid and reliable (ICC 0.81-0.95) but required expertise, specialized equipment, and was time-consuming. MMT, although frequently used, shows variable validity and reliability and is highly subjective.

Conclusion: Muscle strength assessment with isometric and isokinetic tests is effective for para-athlete classification. However, more standardized muscle strength assessment methods are needed to ensure a more objective classification of para-athletes.

Keywords: muscle strength, para-athletes, isometric test, isokinetic test, muscle manual testing, classification

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BACKGROUND

TextMuscle strength assessment is a significant part of routine clinical examination. In para-sport, accurate and reliable muscle strength assessment is essential for monitoring injury risk, monitoring the effectiveness of rehabilitation or strength training programs, and for sport classification purposes (Fliess Douer et al., 2021).

Based on data from the Ministry of Health of the Republic of Indonesia in 2017, the prevalence of people with disabilities in

Indonesia reached 11,580,117 people, the prevalence of people with disabilities with physical impairments reached 3,474,035 people, while the prevalence of national professional para-athletes was only 1,935 people. With the vast prevalence of people with disabilities in Indonesia, there are only 23 athletes who are included in the Tokyo 2020 Paralympic Games classification. According to data from the National Paralympic Committee of Indonesia (NPCI), impaired muscle power is the second most common component experienced by para-athletes after limb deficiency. The prevalence of impaired muscle power increased from 17% to 20%.

Various methods are available to assess muscle strength, such as isokinetic or hand-held dynamometry and manual muscle testing (MMT). Isokinetic dynamometry is the gold standard for evaluating muscle strength (de Araujo Ribeiro Alvares et al., 2015). Isokinetics can examine various types of contractions, namely concentric, eccentric, and isometric. However, testing using isokinetics takes a long time, which means that the method of assessing muscle strength with isokinetics is less practical when compared to other methods. The following muscle assessment method is manual muscle testing (MMT). MMT is a significant component of many para-sport classification systems, and it is often considered a suitable method for assessing muscle performance as it is short and does not require specialized instrumentation. However, MMT assessment is highly subjective, especially for testing larger muscles. MMT only assesses isometric contractions and may be less suitable for detecting specific physical performance (Kollock et al., 2015).

Based on the explanation above, researchers are interested in conducting research with a Systematic Review of muscle strength assessment in para-sport athletes. One form of follow-up is to further study and search for data on tools or measuring instruments on para-athletes to see the characteristics of muscle strength assessment methods and determine the validity and reliability of several muscle strength assessments for sports classification purposes.

SUBJECTS AND METHOD

1. Study Design and Search Strategy

This was a systematic review, a specific research methodology or research and development conducted to collect and evaluate a study related to a particular topic focus. This research was conducted according to the methods described in the Cochrane Handbook for Systematic Reviews of Interventions and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The activities include determining the search strategy for data and information sources, selecting the study through quality assessment according to eligibility criteria and quality assessment instruments, data synthesis, and data extraction.

Data searches on several databases (PubMed, Scopus, and Google Scholar) were conducted. The keywords and boolean search used in the literature search were “muscle strength” OR “muscle power” AND “assessment” OR “outcomes” AND “isometric contraction” OR “isotonic contraction” AND “para-sports” OR “para-athletics” AND “paralympic”.

2. Population and Sample

This study's population consisted of physically impaired para-athletes. The population criteria included individuals with muscle strength impairments involved in various para-sports at international, national, and regional levels. This research incorporated 17 studies with a total sample size of 628

participants. Each study had a varied sample, including male and female athletes competing in various para-sports.

3. Inclusion and Exclusion Criteria

The eligibility criteria in this study include inclusion and exclusion criteria. The inclusion criteria in this study are: cross-sectional study design, including individuals with physical limitations, especially muscle strength impairments, participating in any para-sport event or activity at the Paralympic, International, National, or Regional level, journal in English and Bahasa Indonesia, the year of publication of the scientific journal is between 2014-2024. Meanwhile, the exclusion criteria in this study are the denotation form of the inclusion criteria.

4. Operational Definition of Variables

Muscle strength is the ability of the muscular system to produce force or strength.

Para sports are sports played by people with physical, visual, and intellectual disabilities.

Para-athlete is an athlete who has a disability or impairment that makes them eligible to compete in para-sport.

5. Study Instruments

The quality assessment in this study used The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for cross-sectional studies. The JBI Critical Appraisal Checklist for cross-sectional studies consists of 8 quality assessment items, including questions about study inclusion criteria, participants and setting, validity and reliability, confounding variables, and the use of appropriate statistical analyses. Each question item was scored with "yes," "no," "unclear," and "not applicable" interpretations, where "yes" was one and "no," "unclear," and "not applicable" were 0. All included journals were assessed by at least two independent reviewers who were para-sport-focused researchers and academics with Systematic Review publications.

6. Data Analysis

Literature selection using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. The Flowchart Diagram in this study uses a review of the Covidence platform. The data synthesis process in this study was carried out by describing and synthesizing narratively, with studies grouped based on the assessment method used, the group tested, and the comparison group used. Data synthesis refers to the research objectives, namely seeing the tools or measuring instruments used to assess muscle strength in para-athletes, seeing the characteristics of muscle strength assessment methods in para-athletes, and knowing the validity and reliability of several muscle strength measurement tools in para-athletes for sports classification purposes.

7. Data Extraction

The results of data extraction in the form of a table consisting of the name of the researcher and the year of journal publication, country, study design, population, interventions, comparison groups, outcomes, sample size, and type of sport.

RESULTS

1. Search Results

Based on the PRISMA method that has been carried out, the results show that from a total of 367 studies identified, 179 studies were excluded, 22 of which were identified as duplicate data from Covidence, and 157 other studies were marked as ineligible studies by Covidence's automation tools. This resulted in 188 studies being screened. Of the 188 screened studies, 159 studies were excluded because they did not meet the inclusion criteria. Therefore, 29 studies were assessed for eligibility, and 12 studies were excluded due to wrong outcomes (n=2),

wrong study design (n=9), and wrong patient population (n=1). Therefore, only 17 scientific journals were used in this study (See Figure 1 for PRISMA flowchart).

2. Characteristics of Included Studies

The characteristics of the studies are summarized in (See Table 1 for characteristics of included studies).

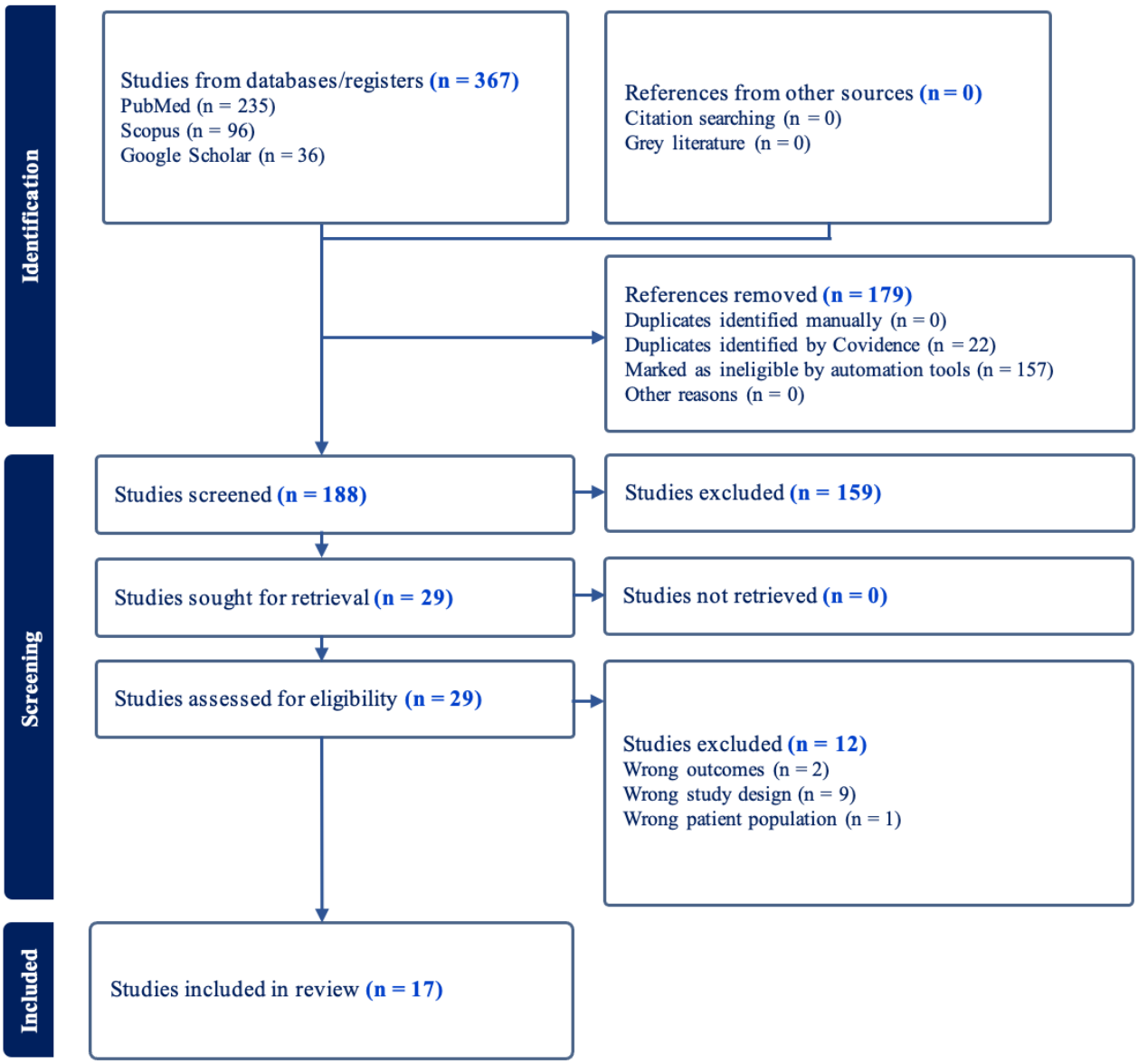

Figure 1. PRISMA flowchart

Table 1. Characteristics of included studies

Author	Country	Design Study	Population	Inter-ventions	Comparison Group(s)	Outcomes	Sample Size	Type of Sport
(Muchaxo *et al.*, 2022)	UK	Cross-sectional study	Athletes with physical impairment	Isometric strength and Manual Muscle Testing (MMT)	Nil	Isometric strength outcomes are adequate sport-specific indicators of impairment in handcycling classification.	62 International Handcycling Athletes	Handcycling
(Iturricastillo *et al.*, 2022)	Spain	Cross-sectional study	Athletes with SCI, lower limb amputation, and other eligible impairment	Bench press test	Category B (Athletes with lower limb amputation n=4 and other eligible impairment n=6)	No significant differences were observed between categories in the rMAT and BP.	17 International-level world-class WB players: Category A (Athletes with SCI n=7)	Wheelchair Basketball (WB)
(Külünkoğlu, Akkubak and Ergun, 2018)	Turkey	Cross-sectional study	Disabled Athletes	Isokinetic dynamometer	Non-disabled participants who do not have any permanent disabilities (n=9)	Significant differences were observed between the groups in terms of all parameters of muscular strength. Upper extremity muscular strength in female WB players was greater than in the non-disabled controls.	19 (Wheelchair basketball players ; n=10)	Wheelchair Basket ball (WB)
(Beckman, Connick and Tweedy, 2016)	Australia	Cross-sectional study	Athlete with brain impairment (RBI)	Isometric multi-joint tests and	Age matched, non-disabled runners (n =	Participants had significant impairments to lower limb	41 male runners : 13 with brain	Para-Running

Author	Country	Design Study	Population	Inter-ventions	Comparison Group(s)	Outcomes	Sample Size	Type of Sport
				Manual Muscle Testing.	28)	strength compared to controls. Imbalance between stronger and weaker sides affected running performance, rather than severity of strength impair-ment.	impaiments (RBI) and 28 non-disabled (NDR)	
(Garcia-Carrillo et al., 2023)	Chile	Cross-sectional study	Athletes with ambulant amputees and SCI	Handgrip strength	Nil	The handgrip strength of the athletes was found to be high, with the dominant hand showing greater strength. However, The athletes showed bilateral asymmetry.	5 male shot put throwing (2 were ambulant amputees and 3 had SCI)	Para-Shot put
(Mason et al., 2020)	UK	Cross-sectional study	Athletes with SCI, impaired arm strength, and no trunk function	Maximal Isometric strength test for flexion and extension around the shoulder and elbow joint	Physically active, able-bodied (AB) participants: n = 30 (15 male, 15 female)	The current results demonstrated the validity of a battery of isometric strength tests, suggesting they can be used to reliably infer strength impairment in WR athletes.	50 people (20 male WR athletes with impaired arm strength and 30 AB participants; 15 male, 15 female)	Wheelchair Rugby (WR)
(Freitas et al., 2021)	Brazil	Cross-sectional study	Athletes with complete SCI below T1	Isokinetic test using a Biodex Isokinetic	Paraplegic non- athletic individuals	Peak torque/weight, work, and muscle power of WB	36 (Wheelchair basketball	Wheelchair Basket ball (WB)

Author	Country	Design Study	Population	Inter-ventions	Comparison Group(s)	Outcomes	Sample Size	Type of Sport
				Dynamometer.	(n=18)	athletes were significantly greater than those of the control group (P < 0.05), which suggest that WB influences the shoulder musculature of those with traumatic SCI.	players: n = 18 and Paraplegic non-athletic: n =18)	
(Hogarth et al., 2019)	Australia	Cross-sectional study	Athletes with physical impairment	Isometric strength tests	Non-disabled participants (n=30)	Strength test battery has utility in Para-swimming classification to infer loss of strength, guide minimum eligibility criteria, and define impact that strength impairment has on performance.	72 (Para-swimmers: n=42 and Non disabled participants n=30)	Para-Swimming
(Mason *et al.*, 2021)	UK	Cross-sectional study	Athletes with strength impaired arms and no trunk function	Maximal isometric strength for assessing proximal arm strength.	Nil	This study demonstrated that the current battery of isometric strength tests and cluster analyses could facilitate the evidence-based development of classifying proximal arm strength impairment in WR.	57 WR athletes	Wheel chair Rugby (WR)

Author	Country	Design Study	Population	Inter-ventions	Comparison Group(s)	Outcomes	Sample Size	Type of Sport
(Ribeiro Neto *et al.*, 2020)	Brazil	Cross-sectional study	Athlete who are manual wheelchair users with spinal cord injury (SCI)	Isokinetic dynamometer using Biodex System 4 as follows: Concentric shoulder abd & add, MVIC, and MVIC of trunk extension	2 group of men with SCI ; High Paraplegia (HP) group: SCI levels T1-T6 and Low Paraplegia (LP) group: SCI levels T7-L3	Our findings indicated significant differences in trunk strength between the HP and LP. Trunk flexion/extension MVIC on an isokinetic dynamometer has not been previously adopted in the context of SCI and was, therefore, a suitable assessment.	54 male with SCI	Wheel chair athletes
(Altmann et al., 2018)	Netherlands	Cross-sectional study	Disabled athletes (at least 18 years) with a minimum of 1-year experience	Maximum isometric trunk strength test using mean isometric force	Nil	Forward trunk strength and acceleration and sprint momentum performance increased with an increase in trunk strength.	27 athletes	Wheel chair Rugby (WR) or Wheel chair Basket ball (WB)
(Yanci et al., 2015)	Spain	Cross-sectional study	Disabled Athletes	Maximal isometric grip strength	Category B (corresponds to levels 3.0–4.5 pts.: n=8)	Higher relative strength compared with AB players may be related to differences in fitness, amount of training, training intensity and/or motivation.	16 WB players: 14 males and 2 females. Devided into 2 category: Category A (level 1.0-2.5) and Category	Wheel chair Basket ball (WB)

Author	Country	Design Study	Population	Inter-ventions	Comparison Group(s)	Outcomes	Sample Size	Type of Sport
							B (level 3.0-4.5)	
(Çobanoğlu et al., 2020)	Turkey	Cross-sectional study	Disabled athletes active in sports for at least 2 years	Cybex isokinetic dynamometer for measured the strength of shoulder rotators	Able-bodied basketball players (n= 18) and sedentary individuals (n=17)	Muscle strength of the shoulder rotator cuff muscles were similar in WBP and AB-BP groups and higher than controls. Concentric and eccentric ER/IR ratio was similar in all groups but ER/IR ratios were lower in WBP compared to the other two groups and normative values.	52 (Wheelchair basketball players: n = 17)	Wheel chair Basket ball (WB)
(Connick et al., 2018)	Australia	Cross-sectional study	Disabled athletes with SCI from classes T51-54	Maximum isometric strength of arm extensors, trunk flexors, forearm pronators, handgrip strength.	Nil	Athletes with no trunk function are at a significant disadvantage compared with those with partial or full trunk function.	32 Interna-tional-level male wheel-chair racers from classes T51-54	Wheel chair Racing
(Liljedahl et al., 2023)	US	Cross-sectional study	Athletes with leg impair-ment	Isometric and dynamic strength test, Manual Muscle	Nil	There is a significant relation of isometric and dynamic strength with sprint power and race	56 para-cyclist: 44 males, 12 females..	Para-Cycling

Author	Country	Design Study	Population	Inter-ventions	Comparison Group(s)	Outcomes	Sample Size	Type of Sport
				Testing (MMT)		speed maps the impact of lower limb impairments.		
(Nowak et al., 2021)	Poland	Cross-sectional study	Athletes with physical impairment (lower-limb impairments)	Handgrip strength test	Types of impairment (2 groups): Limb deficiency and leg length difference.	Amputee football requires a high level of power from players. There was a strong correlation between hand- grip strength	23 polish male Amputee Footballers (AF) players	Amputee Football
(Kokaly et al., 2023)	Spain	Cross-sectional study	Athletes with Cerebral Palsy and unilateral spasticity.	Isometric muscle strength test	Nil	Knee extension strength in the non-impacted leg was wider than impacted leg. No significant difference was found in knee flexor strength. 77% of participants showed asymmetry in lower limb strength levels >10% (muscle strength imbalance).	9 male para-footballers	Para-footballers

All studies included in this research used a cross-sectional study design, with the population or participants having eligible criteria of physical impairment. The total number of participants in these studies was 628, with six studies involving only male participants. The comparison group in these studies varied widely consisting of able bodied and non-able bodied from athlete and non-athlete populations, with seven studies having no comparison group. Participants took part in several different para-sports (n=9), including handcycling, wheelchair basketball (WB), para-running, para-shot put, wheelchair rugby (WR), para-swimming, wheelchair racing, para-cycling, and para-footballers. Wheelchair basketball (WB) is the most common sport followed in these studies. Studies usually test the strength of several muscle groups, but this study mostly tested muscle strength in the upper limbs.

3. Quality of Assessment

The quality assessment of the included studies is shown in (See Table 2 for quality ratings using The Joanna Briggs Institute Checklist for assessment of cross-sectional studies).

Table 2. Quality ratings using The Joanna Briggs Institute Checklist for assessment of cross-sectional studies

Author	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects and the settings described in detail?	Was the exposure measured in a valid and reliable way?	Were objective, standard criteria used for measurement?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcomes measured in a valid and reliable way?	Was appropriate statistical analysis used?	Total Score/ 8
Muchaxo, 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Iturricastillo, 2021	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	7
Kulunkoglu, 2018	Yes	Yes	Yes	Yes	Unclear	No	Yes	Yes	6
Beckman, 2016	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	7
Garcia-Carrillo, 2023	Yes	Yes	Yes	Yes	Unclear	No	Yes	Unclear	5
Mason, 2020	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	7
Freitas, 2021	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	7
Hogarth, 2019	Yes	Yes	Yes	Yes	Unclear	No	Yes	Yes	6
Mason, 2021	Yes	Yes	Yes	Yes	Unclear	No	Yes	Yes	6
Ribeiro Neto, 2020	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	7
Altmann, 2018	Unclear	Yes	Yes	Yes	Unclear	No	Yes	Yes	5
Yanci, 2015	Yes	Yes	Yes	Yes	Unclear	No	Yes	Unclear	5
Cobanoglu,	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	7

Author	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects and the settings described in detail?	Was the exposure measured in a valid and reliable way?	Were objective, standard criteria used for measurement?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcome measured in a valid and reliable way?	Was appropriate statistical analysis used?	Total Score/ 8
2020 Connick, 2018	Unclear	Unclear	Yes	Yes	Unclear	No	Yes	Yes	4
Liljedahl, 2023	Yes	Yes	Unclear	Unclear	Yes	Unclear	Unclear	Yes	4
Nowak, 2021	Unclear	Unclear	Unclear	Yes	Unclear	No	Unclear	Yes	2
Kokaly, 2023	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	6
Total Score									**99/17 = 5,8**

There was 1 study with a total score of 2, 2 studies with a total score of 4, 3 studies with a total score of 5, 4 studies with a total score of 6, 6 studies with a total score of 7, and 1 study with a total score of 8. The study with the highest total score was the journal with author Muchaxo, published in 2022, while the study with the lowest total score was the journal with author Nowak, published in 2021. The average quality assessment score on 17 scientific journals using the JBI Critical Appraisal Checklist for cross-sectional studies was 5.8.

4. Methods Used to Assess Muscle Strength

The majority of studies assessed muscle strength using isometric strength tests, with ten studies. With four other studies using isokinetic tests, two studies using handgrip strength tests, and one study using bench press tests. Among them, there were four studies that combined two measurements; namely, three studies assessed muscle strength using an isometric strength test and manual muscle testing (MMT), and one study used an isometric strength test and handgrip strength test. Only two studies included validity data from the muscle strength assessment, two studies included reliability data, three studies included both validity and reliability data, and the remaining ten studies did not include either data.

5. Strength Outcomes

Many athletes show asymmetry in muscle strength between the dominant and non-dominant side or between the impaired limb and the healthy limb in para-athletes. Measurement of muscle strength with isometric strength tests (e.g., on arms and legs) has a relationship in classifying the level of impairment and inferring impaired muscle strength in several sports (wheelchair rugby and hand cycling). In other studies, manual muscle testing (MMT) has also shown potential for use in the classification of athletes, especially in para-cycling.

DISCUSSION

This study is a systematic review that generally aims to assess and synthesize evidence related to the assessment of muscle strength in para-athletes. Other objectives of this study were to look at what tools measure muscle strength in para-athletes, to look at the characteristics of muscle strength assessment methods in para-athletes, and to determine the validity and reliability of some muscle strength assessments for sports classification purposes. Seventeen cross-sectional studies met the inclusion criteria for this study, which included various para-sports such as hand cycling, wheelchair basketball (WB), para-running, para-shot put, wheelchair rugby (WR), para-swimming, wheelchair racing, para-cycling, and para-footballers. Wheelchair basketball (WB) was the most common sport among the participants. The study involved a total of 628 participants, all of whom were physically challenged. The included studies had diverse comparison groups, consisting of able-bodied and non-able-bodied individuals from both athletic and non-athletic populations. Seven studies did not have a comparison group, which may affect the generalizability of the findings.

The results of this study demonstrate the importance of analyzing and evaluating muscle strength measurements in supporting the classification process of paralympic athletes and revealing the influence of impairment on muscle strength and sports performance. In particular, this study highlighted various muscle strength assessment methods ranging from isometric strength test, isokinetic test, handgrip strength test, bench press test, and manual muscle testing (MMT). In some studies, the isometric strength test is valid and reliable for measuring muscle strength, especially in paralympic classification (Beckman, Connick and Tweedy, 2016). With intraclass correlation coefficients (ICC) ranging from 0.85 to 0.97 or higher (Hogarth et al., 2019) and coefficients of variation (CV) of 8.4% or less (Mason et al., 2020). This method also provides consistent and highly objective results. However, the assessment method has the disadvantage of only measuring static strength and has limitations in accounting for dynamic strength.

In addition, manual muscle testing (MMT) is also widely used to assess muscle strength. However, they are generally considered less reliable than isometric strength tests because their validity and reliability vary and are highly subjective depending on the skill of the examiner and the standardization of the testing procedure. The isokinetic test is also a muscle strength assessment method that is considered valid and reliable for measuring muscle strength, as it is an objective test and has high reliability, which shows intraclass correlation coefficient (ICC) values ranging from 0.81-0.95 (Beckman, Connick and Tweedy, 2016). However, the drawback of such assessment methods is that they require expensive specialized equipment and trained examiners to operate the tools. In addition, the method is time-consuming compared to other methods.

This review was researched using a comprehensive and systematic search for data, data extraction, and quality assessment procedures. The evidence for testing muscle strength in the study population was mainly derived from the isometric strength test method. Results showed that methods such as isometric strength and isokinetic tests are valid and reliable for classifying paralympic athletes despite their limitations. This study has limitations because there is a lack of uniformity in testing methods to assess muscle strength across studies. Therefore, further research is needed, such as more diverse muscle strength assessment methods and populations, to develop more standardized evidence-based methods supporting more objective para-athlete classification.

AUTHORS CONTRIBUTIONS

Talitha Qanitah is the leading researcher who contributed to the article's search, collection, screening, and writing. Mr. Suryo Saputra Perdana is the supervisor who has provided thorough guidance, input, and supervision during the research.

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CONFLICT OF INTEREST

There is no conflicts of interest in this study.

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