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The Manual Ability Classification System: A Scoping Review

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Doreen Bartlett

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The Manual Ability Classification System: A scoping review

--Manuscript Draft--

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Order of Authors Secondary Information:	
Abstract:	<p>Purpose: To examine the use of Manual Ability Classification System (MACS) and to identify gaps in the literature by conducting a thorough search of existing publications from 2006 to March 2013.</p> <p>Method: An extensive literature search included fifteen databases, using the search terms "Manual Ability Classification System" or "MACS" to retrieve relevant abstracts. The guidelines proposed by Arksey and O'Malley and Levac and colleagues were followed.</p> <p>Results: 161 articles were identified for final inclusion. The review identified literature that supports the reliability, validity and stability of the MACS.</p> <p>Conclusion: The MACS could be considered as a standard classification for categorizing children with CP based on manual abilities. The MACS can be reliably used for children between 4 and 18 years and adults between 18 and 24 years. The use of the MACS is expected to increase; further work is required to explore the use of the MACS in clinical practice.</p>

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Educational Institution

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PhD

Degree Awarded (or Sought)

TITLE PAGE

Title: The Manual Ability Classification System: A scoping review

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At the time the manuscript was prepared, Deepa Jeevanantham, and Emily Dyszuk were graduate students at Western University, London, Ontario, Canada

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MACS Scoping Review

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Dear Editor,

Thank you very much for accepting our manuscript. The reviewers comments were valuable in shaping the manuscript. Please see below for the response to the reviewers. In addition, the uses of the MACS in page 5 are revised. The psychometric properties part is removed from the independent variable category and lumped together with standard criterion and renamed as psychometric testing. We think it better fits this way. I couldn't do the suggested changes in the abstract section due to word limit.

Thank you.

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Introduction

Palisano and colleagues were the first to apply the concept of classifying the extent of involvement of children with cerebral palsy (CP) primarily based on self-initiated movements in their everyday lives and developed the Gross Motor Function Classification System (GMFCS).^{1,2} The GMFCS is a reliable and valid standard classification system for measuring the functional abilities of children with CP.³⁻⁵ The GMFCS was expanded and revised (GMFCS- E&R) in 2008.⁶ The GMFCS, including its most recent version, has been an important contribution to the field of CP, providing common language for communication among professionals and parents. The Manual Ability Classification System (MACS) was developed by Eliasson and colleagues in 2006⁷ and parallels the GMFCS in many ways.

The MACS is a five-level classification system that classifies the manual ability of children with CP based on self-initiated ability to manipulate objects in the home, school, and community. Children at level I can perform all manual tasks and can handle objects easily and successfully, whereas children at level V are completely dependent and demonstrate very limited ability in performing even simple actions. The levels are determined by a parent or caregiver who regularly observes the child's functions in daily life, in collaboration with a health care professional.⁷

Similar to the GMFCS – E&R, the MACS classifies the child's performance (i.e. what the child does, rather than what the child can do). The MACS is designed for children between 4 and 18 years of age and the levels are determined based on age-appropriate activities using objects within the child's typical environment.⁷ Another

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4 important aspect of the GMFCS and the MACS is that they both consider the functional
5 ability of children with CP rather than focusing on their disability. The MACS is an
6 important classification **system** that provides a simple description of the manual
7 functioning in everyday life of children with CP. Although many studies have been
8 published including the MACS since its development in 2006, there is lack of
9 information about its use in the literature. The MACS is gaining international attention
10 and at this stage it is important to understand the extent of its use in the literature,
11 evidence of psychometric properties, and information about dissemination. Conducting
12 a review on the above aspects also helps in identifying gaps which may provide
13 directions for future research. Therefore it is of interest to explore the following research
14 questions using a scoping review: has the use of the MACS increased **over time** since
15 its publication? In what types of publications has the MACS been used? In which
16 countries has the MACS been used? How has the MACS been used? What is the
17 available evidence for the psychometric properties of the MACS? Has the MACS been
18 correctly used? **The purpose of this study was to understand the extent to which the**
19 **MACS has been used and reported in written formats, and to identify gaps in the**
20 **literature, by conducting a scoping review.**

46 **METHOD**

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50 A scoping review is an excellent approach for identifying literature of interest in
51 covering the broad scope of a research question. In addition to providing a breadth of
52 knowledge, the scoping review also facilitates identification of gaps in the literature to
53 make appropriate recommendations for future research. In this scoping review the
54 methodology developed by Arksey and O' Malley⁸ and recommendations made by
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4 Levac et al⁹ were followed. Specifically, the following first five stages were used:
5
6 identifying the research questions, identifying relevant studies, study selection, charting
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8 the data, and collating, summarising, and reporting the results.
9

10 11 12 **Search strategy** 13

14
15 After clarifying the research questions and purpose, consultation with the Health
16
17 and Rehabilitation Science librarian on effective search strategies, databases, and
18
19 search terms was the first step to maximize the efficiency and quality of the literature
20
21 search. An online literature search was performed on fifteen databases including
22
23 Abledata, Amed, CINAHL, Cochrane Library, Dissertations and Theses, EMBASE,
24
25 Health and Psychosocial Instruments, PEDro the Physiotherapy Evidence Database,
26
27 Physical Education Index, Proquest Nursing and Allied Health Source, PsycINFO,
28
29 PubMed, Scopus, SocINDEX, and Sociological Abstracts, using the terms "Manual
30
31 Ability Classification System" or "MACS". Articles published since the inception of the
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33 MACS in 2006 until March 2013 were included in the scoping review.
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41 **Inclusion and exclusion criteria** 42

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44 Screening for eligibility was done in two stages. Because the purpose of this
45
46 scoping review was to identify the dissemination of the MACS in written format, all types
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48 of publications including original contributions, review articles, case reports, conference
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50 presentations, commentaries, book sections, newsletters, and dissertations were
51
52 included. A two-stage process was used to screen publications for inclusion. In stage 1,
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54 all types of publications that used the term Manual Ability Classification System were
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56 included. Other publications referring to or using the term MACS not meaning the
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4 Manual Ability Classification System were excluded. Stage 2 inclusion and exclusion
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6 criteria were derived after reading the abstracts of publications obtained in stage 1. In
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8 stage 2, publications in which the MACS was used as a variable or was the main focus
9
10 were included. Articles published in languages other than English, when the MACS was
11
12 not used as a variable, or the main focus, as well as publications in which the MACS
13
14 was used in populations other than CP were excluded. The MACS was originally
15
16 developed for children up to 18 years of age; however, it has been validated for ages
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18 older than 18 years;¹⁰ therefore, the articles in which the MACS was used in adult
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20 populations were included.
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25 26 27 **Review process and data extraction** 28 29

30 Each abstract was reviewed by two independent reviewers and screened for
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32 eligibility based on a consensus process. A third reviewer was consulted when initial
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34 consensus was not reached. Each reviewer independently documented details on year
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36 of publication, type of publication, country of origin, psychometric properties, how the
37
38 MACS was used, study design, and whether it was used appropriately.
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43 The number of publications for each full year (2006 to 2012) that included MACS
44
45 were categorized into peer-reviewed and non-peer-reviewed publications. Articles
46
47 published in 2013 were excluded for this part of the scoping review because the search
48
49 was done only up to March 2013 and inclusion of these data would be misleading. The
50
51 original research studies, review articles, and case reports were included in peer-
52
53 reviewed publications. The conference presentations, commentaries, book sections,
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55 newsletters, **letters to editor**, and dissertations were included in non-peer-reviewed
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4 publications. The book section was included in non-peer-reviewed publications because
5
6 of the less rigorous nature of the peer review process. The conference presentation
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8 titles and abstracts were compared with the titles and abstracts of the full length articles
9
10 to verify the proportion of conference presentations that were later published as full
11
12 length articles.
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17 Full length articles were categorized according to their country of origin. The
18
19 country in which the research was conducted is an early indicator of adoption and use.
20
21 Only full length articles were included for this part of the review and all other types of
22
23 publications were excluded because other types of publications did not indicate the
24
25 country in which the research was done. For full length articles in which the country of
26
27 origin was not mentioned, the country of the first author was selected.
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32
33 The uses of the MACS were classified into five categories: sample descriptor,
34
35 independent variable, dependent variable, informative, and psychometric testing. The
36
37 category sample descriptor refers to the articles in which the MACS was used to
38
39 describe the sample. Publications in which the MACS was used as an independent
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41 variable were classified as 'independent variable'. Publications were categorized as
42
43 dependent variable if the MACS was used as an outcome measure. Publications in
44
45 which the MACS was used as a main variable of discussion such as reviews,
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47 commentaries, and letter to editor were classified as 'informative' and publications in
48
49 which the psychometric properties of the MACS were tested or that used the MACS as
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51 a standard criterion were classified as "psychometric testing".
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4 In addition to the above categories we also documented information about study
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6 designs. Detailed descriptions of the definitions used to classify study designs are
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8 provided in **Table 1**.
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12 Consensus between reviewers was achieved on every step of the scoping review
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14 process. Consensus between the two initial reviewers was reached immediately in 88%
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16 of cases, following discussion in 10% of cases, and a third reviewer was consulted in
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18 2% of cases.
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22 23 **RESULTS**

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26 Figure 1 illustrates the process of screening the articles for eligibility. The
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28 literature search on 15 databases yielded 1133 articles; 519 duplicates were removed
29
30 yielding a new total of 614 publications. Of the 614 remaining publications, 436 articles
31
32 were excluded because the term "MACS" was not referring to the Manual Ability
33
34 Classification System. The remaining 178 publications used the term the Manual Ability
35
36 Classification System appropriately, meeting the inclusion criteria. An additional 17
37
38 articles were excluded due to various reasons, including the MACS not being used as a
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40 variable, the MACS not being the primary focus (eg. used only as a reference in the
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42 background information or discussion), articles published in any language other than
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44 English, and the MACS not being used appropriately with the target population (**i.e**
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46 **individuals with CP**). Ultimately, 161 articles were included in the scoping review. All
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48 types of publications were included, which resulted in 106 original **research studies**, 36
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50 conference presentations, 4 review **articles**, 3 case reports, 2 commentaries, 3
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4 newsletters, 4 book sections, 2 dissertations, and 1 letter to editor. A full reference list
5
6 and details of the data extraction are contained in the supplementary file.
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8

9
10 Figure 2 illustrates the number of publications that used the MACS each year
11 since its inception. There was a steady increase in peer-reviewed publications that
12 included the MACS from 2006 to a relatively steady state of 26 to 30 publications per
13 year after 2010. The non-peer-reviewed publications reached a peak in 2010; however,
14 the proportion of conference presentations that took the form of full-length articles and
15 were disseminated in peer-reviewed publications (from 2006 to 2012) was only 28%.
16
17 Figure 3 shows the adoption of the MACS in different continents. More publications
18 including the MACS originated in Europe compared to any other continent.
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30 Table 1 provides description of the research designs. Table 2 contains a
31 summary of the number of articles by use including articles that explored the
32 psychometric properties of the MACS. The findings showed that the MACS was used as
33 one of the criteria in sample selection and sample description, not only in experimental
34 studies, but also in other research designs such as descriptive, measurement,
35 correlation, comparative, and qualitative studies as well as in case reports. The MACS
36 was used as one of the variables in various studies that focused on the relationship
37 between the MACS and other measures or classifications. The MACS was used as an
38 outcome variable in only a few studies. Of the 6 identified publications in which the
39 MACS was used as a dependent variable, there were 3 conference presentation
40 abstracts, 2 experimental studies, and one case report. The MACS was acknowledged
41 as an important classification system in publications such as reviews, commentaries,
42 and a letter to editor. The MACS was used in measurement studies that focused on the
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4 **psychometric properties of the MACS** and as a standard criterion to determine the
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7 validity of 3 upper extremity skills measures.

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10 **In previous studies**, validation of the MACS was initially established through a
11
12 literature search and consultation and consensus with expert groups.⁷ Content validity
13
14 was further explored by interviews with parents and therapists.¹¹ Findings in these
15
16 validity studies demonstrated that the descriptions of each level and the difference
17
18 between the levels of the MACS is clear and meaningful in describing the performance
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20 of manual tasks of children with CP. In this scoping review, 9 publications were
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22 identified which focused on reliability of the MACS. Details on reliability values are
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24 provided in table 3. The inter-rater and intrarater reliability of the MACS has been
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26 explored using the intraclass correlation coefficient (ICC) and Kappa coefficient. In
27
28 summary the ICC values were greater than 0.9 for children **aged between 4 and 18**
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30 **years**^{7, 12-18} and 0.8 for adults.¹⁰ The kappa coefficient was 0.55 for children under 2
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32 years of age and 0.67 for children between 2 and 5 years of age. The MACS is stable
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34 over a period of 12 months for children with CP aged 11 through 12 years (ICC =
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36 0.92).¹⁹ Recently, Ohrvall and colleagues reported the stability of the MACS over time
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38 for children with CP between 4 and 17 years of age with an ICC value of 0.96 and 0.97
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40 for ratings at one year interval and 3 to 5 year interval.²⁰
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49 **DISCUSSION**

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53 This review provides evidence on the adoption, inclusion, and use of the MACS
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55 **as reported in the literature**. The overall findings of the review demonstrate that there
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57 has been a relatively steady increase in the inclusion of the MACS in peer-reviewed
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4 publications since 2006 and that the MACS is used in many different types of
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6 publications. The MACS has captured international attention and is used worldwide
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8 primarily as a **sample descriptor and independent variable and less often as a**
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10 **dependent variable.** The MACS is a reliable, stable, and valid classification system that
11
12 can be used to classify children with CP aged 4 to 18 years based on their hand
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14 function. In most cases, the MACS has been applied to children with CP, but in few
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16 instances its use has been generalized to other populations without sufficient
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18 psychometric testing for those groups.
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25 Since its inception, the MACS has been used in various types of publications for
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27 many purposes. Knowledge translation emphasizes actual use of knowledge in practice;
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29 however, dissemination is an important and essential first step in knowledge synthesis
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31 and translation.²¹ The use of the MACS in different types of publications reveals
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33 different ways of spreading knowledge of the MACS. This scoping review supports the
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35 evidence of knowledge creation and dissemination; further work on actual use of the
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37 MACS may shed light on other aspects of the **knowledge-to-**action cycle.
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43 “In health care, invention is hard, but dissemination is even harder”.^{22.pg2}
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45 Journals, conferences, seminars, books, newsletters, and reports are all venues of
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47 scholarly communication; however, the nature and the extent of peer review may differ.
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49 The early adopters typically obtain information from researchers through social
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51 interactions; including conferences.²² Therefore the less rigorous peer reviewed venues
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53 of scholarly communication and non-peer-reviewed publications should not be
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55 overlooked. Our scoping review identified a steady increase in the rate of peer-reviewed
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57 publications addressing the MACS each year since the development of the MACS to a
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4 relatively steady state in 2010. The review also identified a peak in the non-peer-
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6 reviewed publications in 2010, with subsequent peer-reviewed publications still pending
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8 for many of these research projects. This shows the impact of the adoption of the MACS
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10 by many researchers.
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15 The country in which the research was conducted is an indicator of the adoption
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17 of a particular measure or technique. The findings of our review showed that the MACS
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19 has captured international attention and is used in all continents except Africa. The
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21 MACS is mostly used in Europe, perhaps because it was developed in Europe.
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25 We are specifically interested in mapping the terrain to understand how the
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27 MACS is used in a variety of publications. The MACS was used as a sample descriptor
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29 or an independent variable in the majority of publications and as a dependent variable,
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31 informative, and to determine the psychometric properties in relatively fewer studies.
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33 Primarily, studies reported specific levels of the MACS enabling generalization of the
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35 results of a specific study to a particular subgroup of the population of individuals with
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37 CP. The MACS levels has been reported to be stable over time²⁰ and therefore can be
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39 used for prognostic purposes. The use of the MACS to determine the validity of other
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41 measures supports the notion that it has an accepted standard to describe manual
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43 functions.
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51 The review supports the evidence for psychometric properties of the MACS.
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53 **Relatively few studies addressed the validity of the MACS. Based on the available**
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55 **evidence** the MACS has good validity. Its content validity has been established through
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57 focus groups, literature review and detailed interviews.^{7,11} Reliability is supported by ICC
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4 values greater than 0.75 (regarded as “excellent reliability”)²³ for children between 4 and
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6 18 years of age and adults aged between 18 and 24 years (although it was not originally
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8 designed for the adult population). Substantial agreement²⁴ has been obtained for
9
10 classification of children between 2 and 5 years of age and only moderate²¹ for children
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12 under 2 years. Therefore the MACS has to be used with caution with younger children.
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14 The MACS was originally developed for children with CP and must be validated before
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16 using it with other conditions. Our review identified a few studies in which the MACS
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18 was used in conditions other than CP; these articles were excluded.
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25 Preliminary evidence on the use of the MACS to predict upper extremity surgery
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27 outcomes has been reported on a small group of people.²⁵ The findings of this study
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29 showed that individuals with CP with high and low MACS groups improved in different
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31 functional domains (i.e high MACS group improved in House functional scale and
32
33 satisfaction and low MACS group improved in hygiene status) after undergoing upper
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35 extremity surgery. This was a retrospective study which was done on a sample of 27
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37 participants, 6 to 54 years of age. Further studies on specific age groups using a
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39 prospective design and larger sample size is required to generalize the results of this
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41 study, or other studies focusing on prediction of future outcomes.
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48 One objective of this scoping review was to identify gaps in the literature. The
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50 findings of this review showed that the construct validity of the MACS has not been fully
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52 explored in order for it to be considered as a gold standard although it is considered an
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54 “accepted standard” as previously discussed. The reliability of the MACS in adults with
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56 CP has been explored in only one study and ought to be replicated on a different
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58 sample. Our review did not identify any studies that explored the use of the MACS in
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4 clinical practice. Further work is required to elucidate the MACS's construct validity,
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6 reliability of use in adulthood and clinical uptake and utility.
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10 In conclusion, there is an emerging use of the MACS in the literature. The
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12 MACS possesses an acceptable standard for classifying manual function of children
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14 with CP and is primarily used in the literature to describe the participants and as an
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16 independent variable. It can be reliably used for children between 4 and 18 years and
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18 adults between 18 and 24 years. The use of MACS is expected to increase and further
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20 work is required to explore its use in clinical practice.
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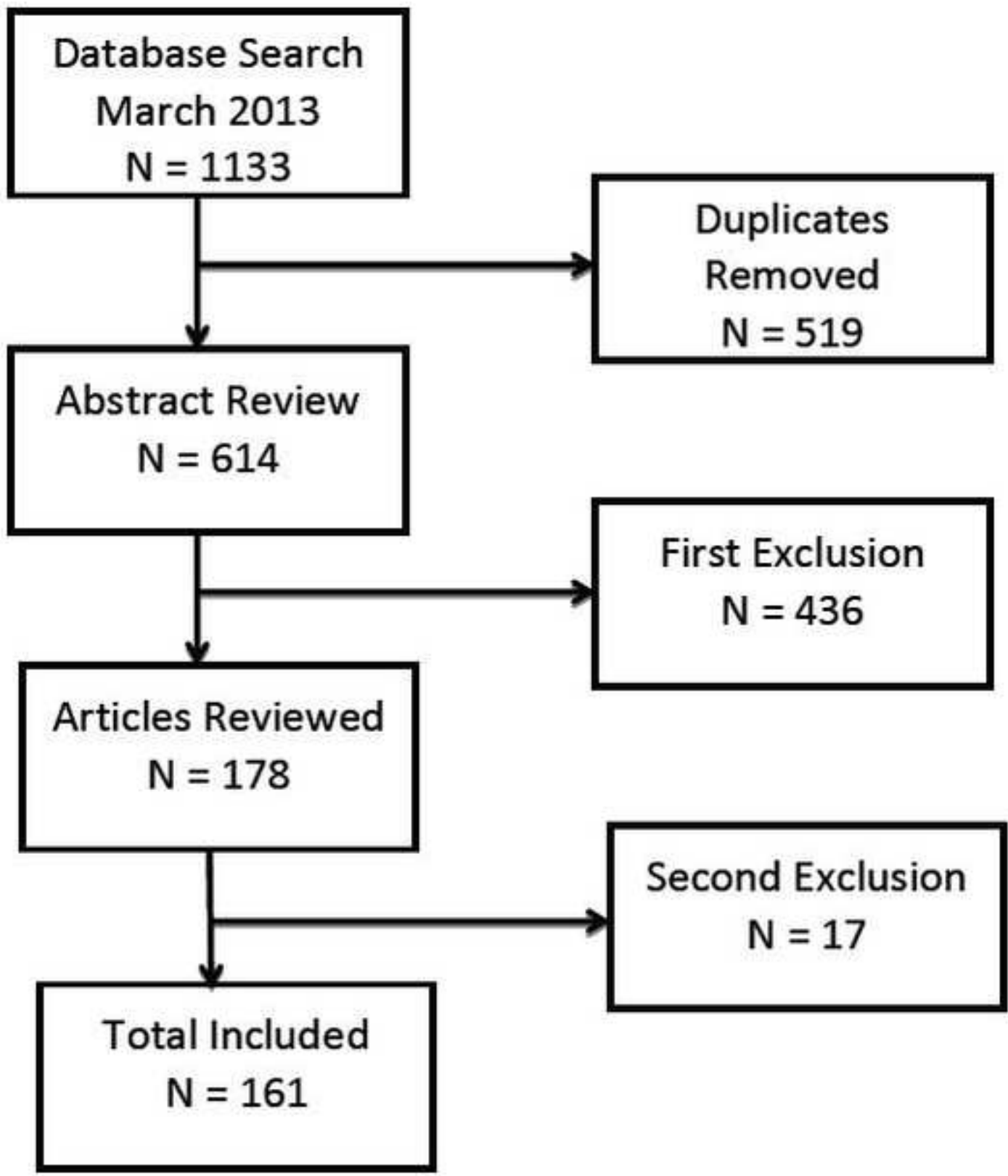
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4 **Figure Legends:**
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7 **Figure1: Data screening process**
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11 **Figure 2: Number of publications that made use of the Manual Ability**
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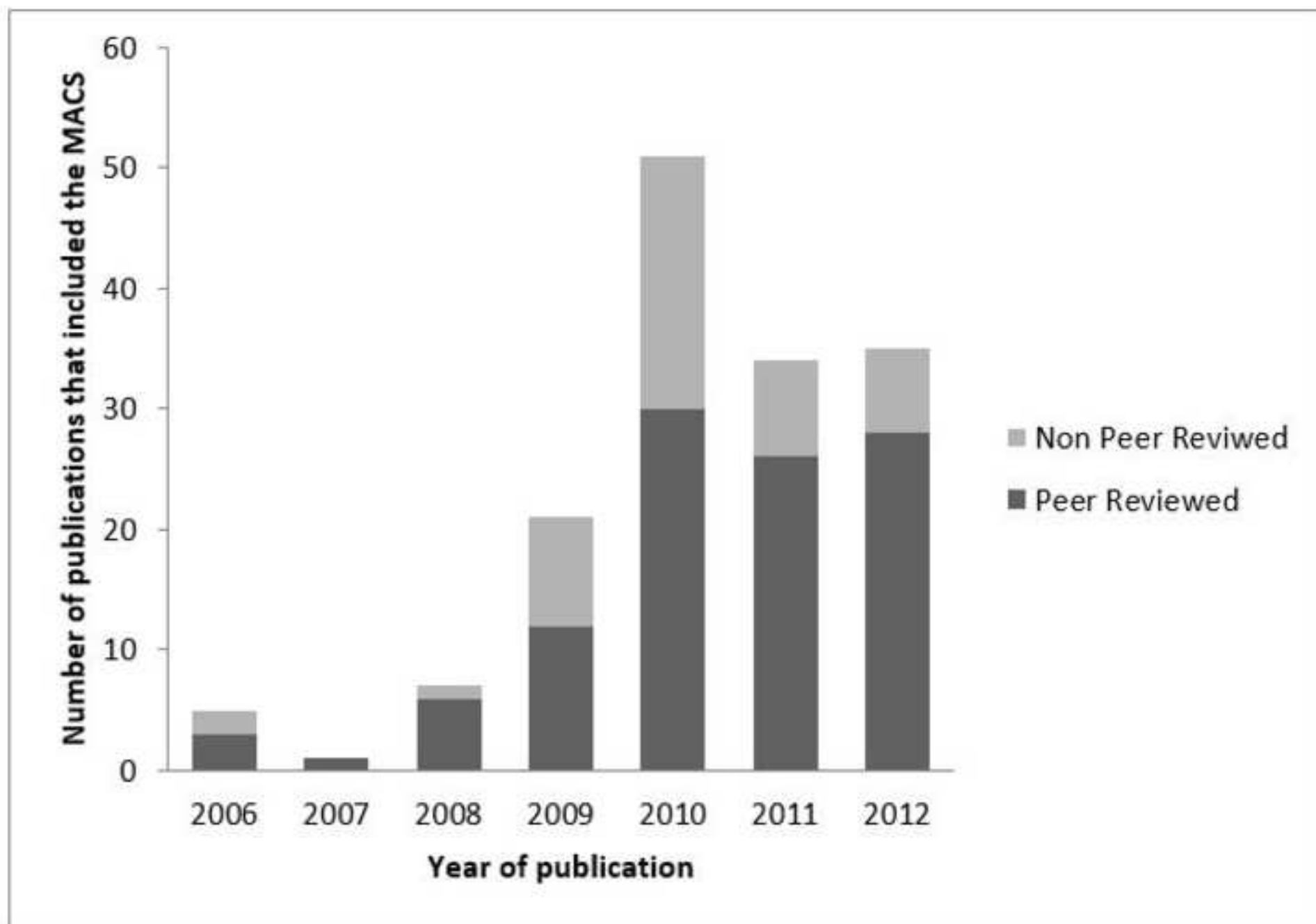
13 **Classification System.**
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15 **Figure 3: Number of publications from the continents that used the Manual**
16 **Ability Classification System. Each publication may be reported under more than**
17 **one continent due to multicenter studies.**
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Figure

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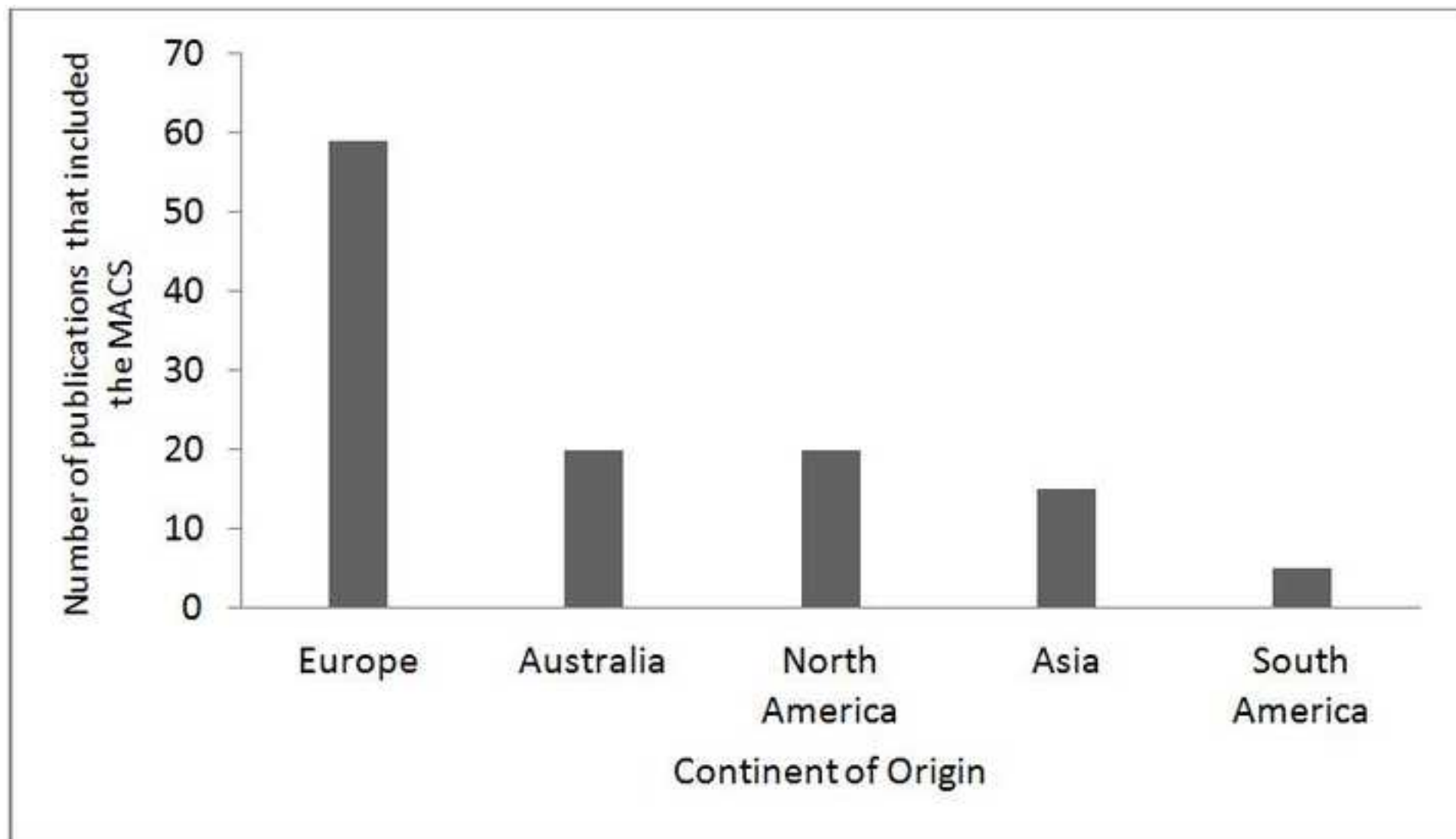


Table 1: Description of the study designs

Study Design	Description	Number of Publications
Measurement studies	Publications that explored the psychometric properties of the MACS and other assessment tools (if the MACS was used in that publication)	26
Descriptive studies	Studies that described a variable or a phenomenon	49
Correlation studies	Studies that explored the relationship between variables	42
Comparative studies	Studies that compared the differences between groups without manipulation of a variable	7
Experimental studies	Studies in which a variable was manipulated	32
Prognostic studies	Studies investigating prediction of outcome	1
Qualitative studies	Studies that described an individual's perspectives	3
Review articles	Studies that reviewed primary articles	5
Case reports	Studies describing one or a small number of participants	5

Table 2: Summary of the uses of the Manual Ability Classification System. The numbers in the table indicate the number of publications.

Use of the MACS in research	Number of publications
To describe the sample	70
As an independent variable	54
The MACS was the main variable of discussion (i.e informative)	8
As an dependent variable	6
For psychometric testing	16

Table 3: Reliability of the MACS

Citation	Type of reliability	MACS version	Age range	Reliability statistics
Eliasson et al. ⁷	Inter-rater reliability	Original version	4 to 18 years	ICC = 0.97
Meeteran et al. ¹⁰	Inter-rater reliability	Original version	18 to 24 years	ICC = 0.83
Plasschaert et al. ¹²	Inter-rater reliability	Original version	1 to 5 years	K = 0.55 (under 2 years of age) K = 0.67 (2 to 5 years of age)
Jang et al. ¹³	Inter-rater reliability	Korean version	4 to 14 years	ICC = 0.92 to 0.96
	Intra-rater reliability	Korean version	4 to 14 years	ICC = 0.96 to 0.98
Akpınar et al. ¹⁴	Inter-rater reliability	Turkish version	4 to 18 years	ICC=0.89 to 0.98
	Test re-test reliability	Turkish version	4 to 18 years	ICC=0.91 to 0.98
Riyahi et al. ¹⁵	Inter-rater reliability	Persian version	4 to 18 years	ICC = 0.96
	Test re-test reliability	Persian version	4 to 18 years	ICC = 0.97
Morris et al. ¹⁶	Inter-rater reliability	Original version	6 to 12 years	ICC=0.7 to 0.9
Mutlu et al. ¹⁷	Inter-rater reliability	Turkish version	4 to 18 years	ICC=0.96
Randall et al. ¹⁸	Inter-rater reliability	Original version	4 to 11 years	K=1

ICC = intraclass correlation coefficient; K=Kappa coefficient

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