# Talent identification and development in judo: A systematic review

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**ORIGINAL ARTICLE**

Submitted: 13 October 2023

Accepted: 15 April 2024

Published: 16 January 2025

**Editor-in-Chief:**

Claudio R. Nigg, University of Bern, Switzerland

**Section Editor:**

Martin Keller, University of Basel, Switzerland

## ABSTRACT

This review synthesizes the existing literature about talent identification and development in judo and provides evidence-based suggestions to help researchers and practitioners in this area. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to identify relevant studies (*n* = 45). The mean quality of the evidence was 94.0%. Most of the studies were published between the years 2014 and 2021 with cross-sectional designs and group comparisons or performance prediction. Studies used batteries of tests focused on expert or advanced samples and measured individual constraints. Few studies examined female samples, psychological skills or biological maturation. Only 20% of the studies used multivariate analyses. On closer examination, there was a high degree of variability in the indicators that were found to discriminate between skilled and less-skilled judo athletes, predict performance and/or predict career pathway. Research in talent identification and development in judo has generally focused on individual constraints related to anthropometric and physiological characteristics, and technical skills in cross-sectional designs. Very little is known about what talent indicators discriminate high skilled judo athletes or predict actual performance or future success. Future research should adopt multidimensional and longitudinal approaches that integrate existing findings about the maturational, psychological and environmental aspects of judo for tracking the most talented judo athletes, especially in female samples.

**Keywords**

*judo, athlete, talent, expertise, selection, development*

Citation:

Aparecida de Souza Ribeiro, A., Zacaron Werneck, F., Guilherme Vieira, J., Sant'Ana, L., Johnston, K., Baker, J., & Macedo Vianna, J. (2025). Talent identification and development in judo: A systematic review. *Current Issues in Sport Science*, *9*(1), Article 011. https://doi.org/10.36950/2024.9ciss011

## Introduction

Most countries invest substantial resources in elite sport systems in order to achieve competitive advantages (De Bosscher et al., 2019; Mazzei et al., 2021; Vaeyens et al., 2009). In this context, talent identification and development (TID) are important for international sporting success (De Bosscher et al., 2006) and this process is believed to benefit from starting early in an athlete's life (Bailey & Morley, 2006; Prieto-Ayuso et al., 2020). Discovering and nurturing athletic talent are dynamic and complex processes where individual, task and environmental constraints interact in determining long-term success (Abbott et al., 2005; Phillips et al., 2010; Rees et al., 2016). Research on sporting talent has grown considerably since the 2000s, predominantly carried out in Europe, in team sports (soccer and basketball), with male samples, using unidimensional approaches, and cross-sectional designs (Baker et al., 2020). Unfortunately, the accuracy of TID programs is low (Güllich & Cobley, 2017) and the scientific evidence on talent predictors in high-level sport is limited, with a high degree of variability in the factors that discriminate skilled and less-skilled athletes (Johnston et al., 2018). This is a research area with many more questions than answers, especially in combat sports such as judo, making it an important venue for further research.

The process of talent identification assumes there is something to be identified; however, there is a lack of clarity regarding what talent is, what it means, and what identification approach is preferred (Baker et al., 2019; Johnston & Baker, 2020; Till & Baker, 2020). The concept of sporting talent ranges from innate capacity or ability, to performance gained through training and experience or even a combination of both (Issurin, 2017; Johnston et al., 2018). Talented young athletes may exhibit both a specific profile of natural characteristics and abilities (nature) and well-developed performance requirements (Pion et al., 2014, 2015). In most research in this area, sporting talent has been assumed through measuring an athlete's demonstration of above-average performance compared with other athletes of the same age, which is seen as increased potential to become an expert, senior elite performer (Brown, 2001; Fransen & Güllich, 2019).

However, above-average performance in early development is not a guarantee of future success and one of the great challenges for researchers, coaches and sport managers has been optimizing the identification, selection and transformation of latent potential into expertise (Baker et al., 2018; Hambrick et al., 2016; Macnamara et al., 2016; Till & Baker, 2020; Tucker & Collins, 2012). Talent identification and development models assume the sooner talented young people are identified and placed in a favorable environment for their development, the greater the probability of reaching the highest level of performance (Vaeyens et al., 2009).

In practice, there is no gold standard approach to talent selection (Johnston & Baker, 2020; Till & Baker, 2020). Generally, coaches use their knowledge and experience, batteries of physical tests and specific skills, and performance in competition to identify young people who they believe have the greatest potential for excellence (Baker et al., 2015; Johnston & Baker, 2020; Roberts et al., 2019). However, most work in this area has focused on physical attributes of talent, which typically favor athletes who have matured relatively earlier than their peers, especially in early stages of athlete development (Pearson et al., 2006).

Given that talent is known to be dynamic and complex, identification and prediction is even more challenging during states of high variability in maturation. Therefore, multidimensional (examining variables that extend beyond the physical profile of athletes) and longitudinal approaches (using evidence that spans over years) are necessary, as they make it possible to understand how talent develops and which characteristics would be valid for predicting future success (Baker et al., 2020; Güllich & Emrich, 2014).

Previous systematic and scoping reviews (Baker et al., 2020; Johnston et al., 2018) about TID have critically appraised sport as a whole or highly popular sports (e.g., football), but few have explored combat sports such as judo. Judo has been part of the Summer Olympic Games since 1964 for men and 1992 for women (Hainline et al., 2017). It is a high-intensity and dynamic intermittent sport characterized by technical/tactical and physical/physiological demands such as grappling, which requires a high level of physical fitness and technical and tactical skills (Boguszewska et al., 2010). Researchers have used generic batteries of test for talent orientation and identification of judo athletes (Pion et al., 2014, 2015; Zhao et al., 2019) and sport-specific performance testing to identify athletes' strengths and weaknesses and to monitor how athletes' performance develops over time (Chaabene et al., 2018). These assessments are important for determining whether a young athlete can successfully meet the physical and motor demands, specific skill requirements, and psychological attributes of this sport, and can be used for training protocols and preparation.

In elite combat sports, federations and coaches typically use junior success as a predictor for long-term senior success (Li et al., 2018), but in judo little is known about the relationship between competitive performance and future success. Furthermore, coaches play a major role during TID in judo and are often used as the gold standard against scientific methods of talent identification (Roberts et al., 2020). In Brazil, for example, despite the high performance obtained in Pan American games, world championships and Olympic Games, there is no systematic program for the development of talented judo athletes. New talents arise from independent and isolated initiatives, particularly from clubs (Silva Filho et al., 2016). Most Brazilian Olympic judo athletes, for example, did not compete in the Brazilian school games (Arantes et al., 2018).

The goal of the present review was to synthesize the available literature of talent identification and development in judo and critically analyze what has been most researched, characterize the methodologies and compile the evolution and trends of associated research.

## Methods

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Liberati et al., 2009; Page et al., 2021). The review methods were established before initiating the research, and protocol registration preceded the search.

### Eligibility criteria

Articles were included after reading their title, abstract and full-text if they met the following inclusion criteria:

1. published between January 1980-February 2021,
2. written in English or Portuguese,
3. were full-text, original articles (books, dissertations, theses, notes, abstracts of congresses, letters to the reader were excluded),
4. contained information on judo athletes (not coaches),
5. contained relevant data from talent identification and/or development (for example, anthropometric, physiological, psychological indicators, the comparison of characteristics, skills, and/or performance, performance prediction, athlete selection and career progression),

6. included skill-level-based comparisons of athletes (expert versus novice, or cadet versus junior), and
7. focused on athletes who were 18 years of age and younger.

Exclusion criteria were:

1. studies exploring relative age effects, and
2. articles that examined weight-based comparisons (e.g., examining weight class differences), sex-based comparisons (males versus females), only sport-based comparisons (e.g., judo compared to karate athletes), and/or non-athlete controls (e.g., elementary school children in gym class).

## Information sources

Searches were conducted on March 6, 2021, in four databases (PubMed, Scopus, SPORTDiscus, and Web of Science) by ASR and JGV. Databases were chosen for their size and widespread catchment of articles in sports science, and search terms were used to identify articles in each database separately. Following this search of the databases, two authors conducted an external search of sources using the same search terms. The external search included reference lists from articles and additional searches on websites.

## Search strategy

To determine appropriate search terms to begin data extraction, a preliminary scoping review of the existing literature was conducted to examine the most common terms and phrases used in the identification and development of talent in the sport of judo. These common words and phrases became the search terms and adopted the Boolean operators "OR" and "AND" to broaden the number of articles for preliminary analysis. These search terms included: ("martial art" OR "combat sport" OR "judo" OR "judoist" OR "judokas") AND ("talent*" OR "expert*" OR "gift*" OR "elite" OR "skill*" OR "select*" OR "champion*" OR "finalist" OR "success*" OR "develop*" OR "identif*" OR "prognos*" OR "predict*" OR "diagnos*" OR "career") AND ("youth" OR "young*" OR "junior*" OR "cadet" OR "adolescent*" OR "athlete"). The equivalent search syntaxes for the other databases are described in the supplementary material.

## Selection process

The studies retrieved in each database were processed in EndNote X9 (Clarivate Analytics, Philadelphia, USA) and duplicate studies were automatically and manually removed (ASR). Titles and abstracts were assessed by two independent researchers according to the eligibility criteria (ASR and FZW), and any conflicts were decided by a third reviewer (JB). The researchers were not blinded to authors, institutions, or journals. Abstracts lacking decisive information were selected for full-text inspection. When some information was absent or incomplete the authors of the studies were contacted by e-mail.

## Data collection process

Relevant data items were defined a priori, to avoid biasing the analyses. ASR and FZW completed initial data extraction independently. In case of discrepancies, JB defined the situation in order to reach a consensus. Data were recorded in Excel spreadsheets created specifically for this systematic review.

## Data items

The following items were extracted from the included articles: name of the author(s), year of publication, journal name, title of the article, study objective, study design (cross-sectional, prospective, retrospective or intervention/short-tracking), total sample size, gender (male, female or both), age of the participants (youth: 6-11 years old; adolescent: 7-17 years old; adult (18+ years old), nationality of participants, skill level of participants (expert, advanced, intermediate, basic, novice or naivete), statistical analysis, and data collection type (battery of tests, interview, and/or secondary source/database). The authors also verified whether there was an explicit definition by the researchers in

relation to the concept of sports talent and/or a theoretical basis drawn from talent development models. All tests and measurements performed in the studies were tabulated. Subsequently, "yes" or "no" was recorded based on whether the study measured some indicator within the following factors: anthropometric and physiological characteristics, biomechanical features, psychological skills, technical skills, tactical/cognitive skills, quantity/quality of practice/training, performance in competition, motor coordination, sociocultural characteristics, including relative age effect, biological maturation, genetic markers, subjective evaluation of coach. Studies that investigated at least four of these factors were considered multidimensional. Finally, according to the objective of our review, studies were classified into diagnosis/group comparison or performance prediction or future success prediction/career pathway or training program/training effect. The descriptive analysis of these data is presented through frequencies, percentages, tables, and graphs.

### Study risk of bias assessment

Following the recommendations of Faber et al. (2016), the methodological quality of the studies was assessed by two reviewers (ASR and JGV) using the critical review forms in Letts et al. (2007) for qualitative studies (containing 21 items) and Law et al. (1998) for quantitative studies (containing 16 items). Each qualitative article was evaluated relative to the following 21 items: objective (item 1), literature reviewed (item 2), study design (items 3, 4 and 5), sampling (items 6, 7, 8 and 9), data collection (descriptive clarity: items 10, 11 and 12; procedural rigor: item 13), data analysis (analytical rigor: items 14 and 15; auditability: items 16 and 17; theoretical connections: item 18 ) and overall rigor (item 19) and conclusion/implications (items 20 and 21). Quantitative studies were assessed to determine whether they included the following 16 items: objective (item 1), relevance of background literature (item 2), appropriateness of the study design (item 3), sample included (items 4 and 5), informed consent procedure (item 6), outcome measures (item 7), validity of measures (item 8), details of the methods (item 9), significance of results (item 10), analysis (item 11), clinical importance (item 12), description of dropouts (item 13), conclusion (item 14), practical implications (item 15) and limitations (item 16). The results per item were coded as 1 (meets the criteria), 0 (does not fully meet the criteria) or NA (not applicable).

A final score expressed in relative value was reported for each study following the scoring guidelines of Faber et al. (2016). This final score was the total of all the scores for a given item divided by the total number of items scored for that specific research project (i.e., 16 or 21 items). We adopted the classifications of Faber et al. (2016) and classified the articles as (1) low methodological quality - with a score < 50%; (2) good methodological quality - scores between 51 and 75%; and (3) excellent methodological quality - with a score of > 75%.

### Synthesis methods

No meta-analysis was planned. A narrative synthesis of the results was provided.

### Reporting risk of bias assessment

Since no meta-analysis was planned, reporting risk of bias assessment could not be performed.

## Results

Phase 1 identified 2,277 articles from the database searches using the keywords listed above, with an English and Portuguese-language restriction imposed. An additional 18 articles were identified through external sources. Removal of duplicates resulted in a total of 1,742 articles. After reviewing the titles and abstracts, 1,628 of these records were eliminated, leaving 114 studies identified for full-text assessment. After a thorough assessment, 69 articles were removed. This left a total of 45 articles that remained in the final study selection (see Figure 1 for a flow diagram of the PRISMA process).

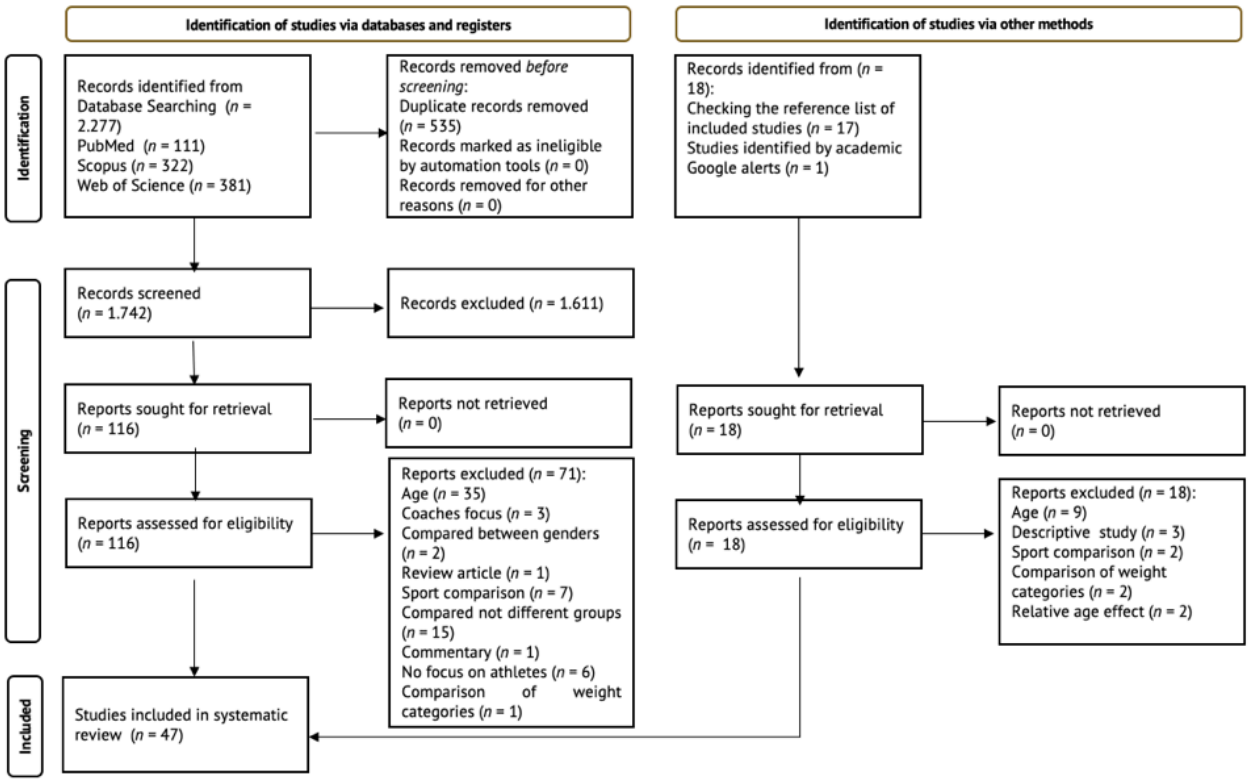


**Figure 1** PRISMA 2020 flow diagram showing number of reports collected and number of eligible studies after the screening process.

## Descriptive Results

Concerning the methodological quality of studies, the most noteworthy results were that (1) the mean score for the 36 selected quantitative studies was 93.0%; (2) the mean score for the 9 selected qualitative studies was 99.0%; (3) 10 publications achieved the maximum score of 100%; (4) no publication scored below 75% (Table 1). Figure 2 illustrates the profile of study publication dates. From these studies, 29 (64.4%) were published in the 8-year period between 2014 and 2021. Only four studies (8.8%) examined elements of talent or talent development frameworks (Barreiros et al., 2014; Massa, Uezu, & Böhme, 2010; Massa, Uezu, Böhme, et al., 2010). Talent development frameworks included the Development Model of Sport Participant (DMSP; Barreiros et al., 2014) and Long-Term Training (LTT; Barreiros et al., 2014; Massa et al., 2014; Massa, Uezu, & Böhme, 2010; Massa, Uezu, Böhme, et al., 2010).

**Table 1**
Risk of bias in included studies

| Study | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Q15 | Q16 | Q17 | Q18 | Q19 | Q20 | Q21 | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agostinho & Franchini (2021) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | 100% |
| Agostinho et al. (2015) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | | | | | | 88% |
| Agostinho et al. (2018) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | 100% |
| Arantes et al. (2018) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 100% |
| Barreiros et al. (2014) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 95% |
| Bliznevsky et al. (2016) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Boguszewska et al. (2010) | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | | | | | | 75% |
| Bonitch-Góngora et al. (2013) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Breviglieri et al. (2018) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 100% |
| Caput et al. (2013) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Courel-Ibáñez et al. (2018) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Detanico et al. (2020) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Detanico et al. (2021) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Elipkhanov & Nemtsev (2013) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | | | | | | 88% |
| Franchini et al. (2005) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Franchini et al. (2011) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | | | | | | 88% |
| Fukuda et al. (2018) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 88% |
| Giudicelli et al. (2020) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Giudicelli et al. (2021) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Harris et al. (2020) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | 100% |
| Helm et al. (2018) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Iermakov et al. (2016) | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 75% |
| Jagiełło et al. (2014) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Julio et al. (2011) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 100% |
| Kons et al. (2020) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Krstulović et al. (2006) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Krstulović et al. (2005) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |

| Study | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Q15 | Q16 | Q17 | Q18 | Q19 | Q20 | Q21 | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kuvačić et al. (2017) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Lech et al. (2014) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Lech et al. (2015) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Lidor et al. (2004) | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 88% |
| Massa, Uezu, Böhme, et al. (2010) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 95% |
| Massa et al. (2014) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 100% |
| Massa, Uezu, & Böhme (2010) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 100% |
| Miarka et al. (2014) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Nikolova & Dimitrova (2018) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Oliveira et al. (2006) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 100% |
| Osipov et al. (2017) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 100% |
| Prieske et al. (2020) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Sánchez et al. (2011) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Štefanovský et al. (2017) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Sterkowicz et al. (2010) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Wazir et al. (2017) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | | | | | | 94% |
| Zaggelidis et al. (2012) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |
| Zeghari et al. (2019) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | 94% |

Q: question; Q1 to Q21: qualitative articles; Q1 to Q16: quantitative articles; more details see in methods section

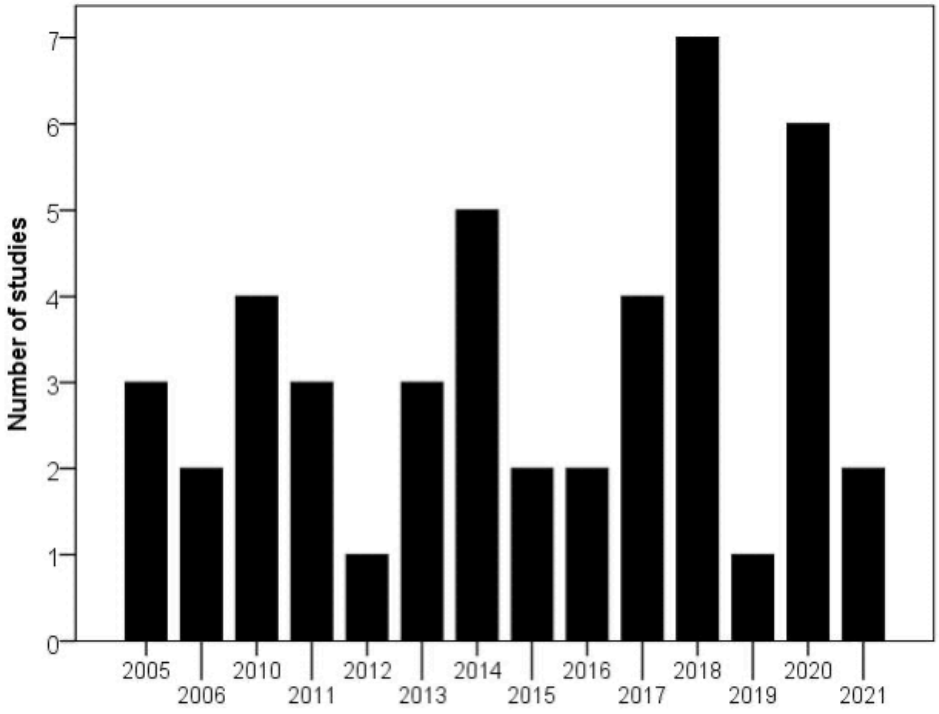


**Figure 2** Number of studies by publication year.

As displayed in Table 2, most studies (48.9%) focused on male participants with just 8.9% examining female-only samples. Just over 33% of studies in the review involved mixed samples of males and females. Most research investigated samples between the ages of 12 and 17 years (48.9%) followed by mixed-aged samples (35.5%). For the skill level comparison, the greatest number of studies examined participants who were expert (28.9%) or advanced (17.8%), while 40.1% of studies used groups of mixed skill levels, which was not surprising given the dominance of comparison-based designs. Athletes from 14 countries were represented among the reviewed studies. Brazil was the country with the greatest representation of articles (*n* = 12 studies or 26.7% of all studies), followed by Poland (*n* = 5 studies or 11.1% of all studies), and Croatia (*n* = 4 studies or 8.9% of all studies). Most studies had sample sizes between 20 to 100 athletes. According to Table 3, the terminology used by the researchers to describe the levels of selection varied greatly, with studies using competitive level (22.2%), elite vs. sub-elite (11.1%), medalist vs. non-medalist (11.1%), more skillful vs. less skilled (11.1%) and so on. Few studies applied multivariate data analyses (20.0%) and 66.7% applied some form of battery of tests.

**Table 2**
Descriptive statistics for sex, age, skill level, sample size and country for the study samples with judo athletes

| **Variable** | ***N* (%)** |
|---|---|
| Sex | |
| Male | 22 (48.9%) |

| Variable | *N* (%) |
|---|---|
| Female | 4 (8.9%) |
| Mixed | 15 (33.3%) |
| Not reported | 4 (8.9%) |
| **Age** | |
| Youth: 6-11 | 3 (6.7%) |
| Adolescent: 12-17 | 22 (48.9%) |
| Adult: +18 | 3 (6.7%) |
| Mixed | 16 (35.5%) |
| Not reported | 1 (2.2%) |
| **Skill level*** | |
| Expert | 13 (28.9%) |
| Advanced | 8 (17.8%) |
| Intermediate | 2 (4.4%) |
| Basic | 2 (4.4 %) |
| Novice | 1 (2.2%) |
| Naïveté | 0 (0.0%) |
| Mixed | 18 (40.1%) |
| Not reported | 1 (2.2%) |
| **Country** | |
| Brazil | 12 (26.7%) |
| Poland | 5 (11.1%) |
| Croatia | 4 (8.9%) |
| Spain | 3 (6.7%) |
| Portugal | 3 (6.7%) |
| Russia | 3 (6.7%) |
| Germany | 1 (2.2%) |
| Belgium | 1 (2.2%) |
| Bulgaria | 1 (2.2%) |
| Greece | 1 (2.2%) |
| India | 1 (2.2%) |
| Israel | 1 (2.2%) |
| Morocco | 1 (2.2%) |
| Ukraine | 1 (2.2%) |
| Mixed | 3 (6.7%) |
| Not reported | 4 (8.9%) |
| **Sample Size** | |
| < 20 | 8 (17.7%) |
| 20-50 | 14 (31.1%) |

| Variable | *N* (%) |
|---|---|
| 51-100 | 12 (26.7%) |
| 101-200 | 4 (8.9%) |
| 201-500 | 4 (8.9%) |
| 501+ | 3 (6.7%) |

*Skill levels replicated from Baker et al. (2015)

As noted in Table 3, most research in this area (64.4%) utilized cross-sectional followed by retrospective designs (20.0%). Only 8.9% of the studies used longitudinal designs and just 6.7% were intervention/short-tracking designs. Most studies were group comparations followed by performance prediction within cross-sectional designs (Figure 3).

**Table 3**
Study design characteristics

| **Study design** | ***n* (%)** |
|---|---|
| Cross-sectional | 29 (64.4%) |
| Retrospective | 9 (20.0%) |
| Prospective | 4 (8.9%) |
| Intervention/short-tracking | 3 (6.7%) |
| **Division into groups** | |
| Competitive level (cadet, junior, senior) | 10 (22.2%) |
| Elite vs. sub-elite (or non-elite) | 5 (11.1%) |
| Medalist vs. non-medalist | 5 (11.1%) |
| More skillful vs. less skilled | 5 (11.1%) |
| Ranking | 2 (4.4%) |
| Athlete vs. non-athlete | 1 (2.2%) |
| National level vs. state level | 1 (2.2%) |
| Selected vs. not selected | 1 (2.2%) |
| Talented vs. not talented | 1 (2.2%) |
| Not applicable | 14 (31.1%) |
| **Data analysis** | |
| Bivariate analysis | 33 (73.3%) |
| (*t* test, correlation, intraclass correlation, ANOVA, ANCOVA, $X^2$ test, Kruskal Wallis test, Mann-Whitney U-test) | |
| Multivariate analysis | 9 (20.0%) |
| (Multiple linear regression, canonical correlation, discriminant analysis, factorial analysis) | |
| Qualitative analysis | 3 (6.7%) |

| **Study design** | ***n* (%)** |
|---|---|
| **Data collection type** | |
| Battery of tests | 30 (66.7%) |
| Secondary source/database | 7 (15.6%) |
| Ex-athletes interview | 3 (6.7%) |
| Mixed | 5 (11.1%) |

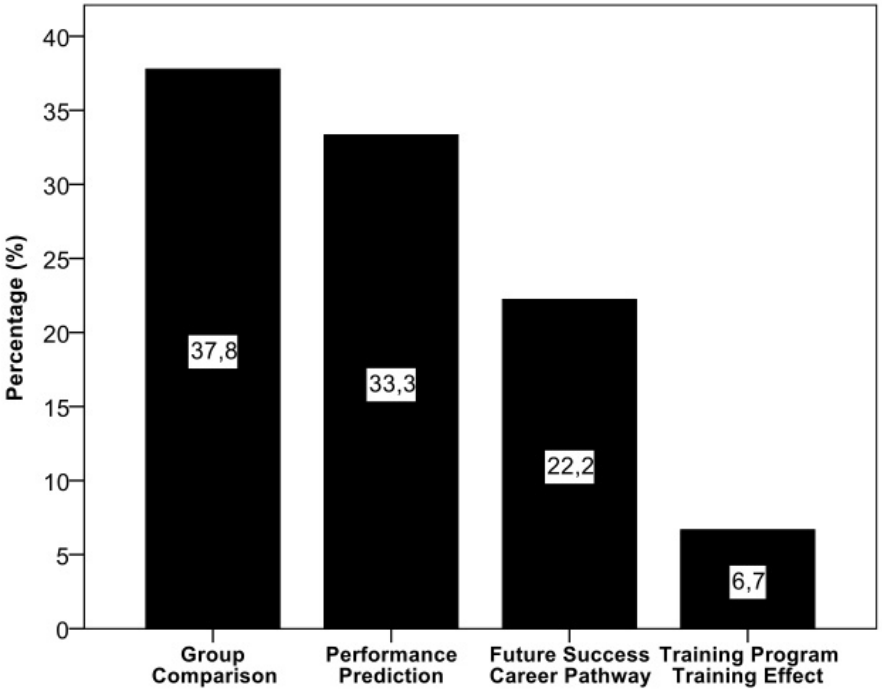


**Figure 3** Study themes.

In this study, a constraint-based theoretical model (Davids et al., 2017) was used to investigate talent identification and development process in judo (Figure 4), utilizing the major research topics that emerged from the analysis, like previous studies (Piggott et al., 2019; Rees et al., 2016; Ribeiro Junior et al., 2021; Sarmento et al., 2018). Dynamical systems theory emphasizes the performer – environment dynamic relationship, in which the broad range of personal, task and environmental constraints impacts how expertise can be achieved (Phillips et al., 2010). In other words, becoming an expert requires a combination of, and interaction between, genetic and environmental factors (Ackerman, 2014). According to this dynamic approach, sporting potential results from the interaction of indicators related to the individual (genetics, capacity, skills, psychological traits), the environment (practice, training, social support, coaches) and the

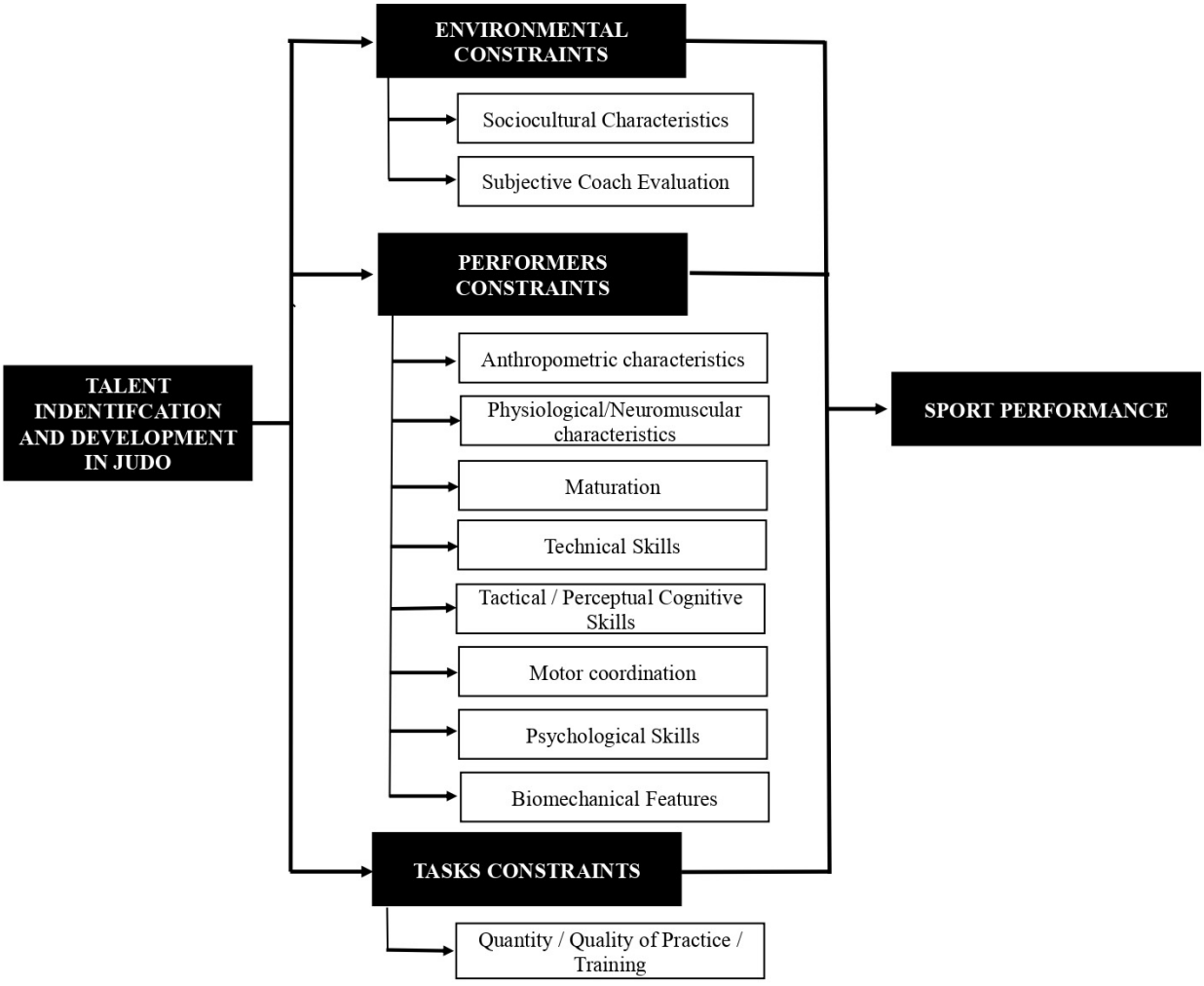


**Figure 4** Scopes of talent identification and development in judo.

sport (Fransen & Güllich, 2019; Phillips et al., 2010; Rees et al., 2016).

The studies included in this review were subdivided into constraint categories according to the types of variables they examined (Figure 4 and Table 4). Of those studies, 40 measured some type of performer constraint while nine examined task and nine environmental constraints. Sixteen studies were multidimensional analyses (at least four indicators measured), but only one study (Bliznevsky et al., 2016) examined simultaneous performer, task and environment constraints. The most common indicators evaluated were anthropometric characteristics (66.7%), physiological characteristics (62.2%) and technical skills (48.9%). Almost half of the studies (44.4%) measured some type of competition performance (ranking, winning, medalist, success). Only six studies measured biological maturation. Task and environmental constraints were more investigated in longitudinal designs.

**Table 4**
Constraint categories according to the types of variables examined

| | **Overall (*n* = 45)** | **Cross-sectional (*n* = 29)** | **Longitudinal (*n* = 16)** |
|---|---|---|---|
| Performer constraints | *N* (%) | *N* (%) | *N* (%) |
| Anthropometric characteristics | 30 (66.7%) | 23 (79.3%) | 7 (43.8%) |
| Physiological characteristics | 28 (62.2%) | 20 (69.0%) | 8 (50.0%) |
| Technical skills | 22 (48.9%) | 15 (51.5%) | 7 (43.8%) |
| Tactical/perceptual cognitive skills | 5 (11.1%) | 3 (10.3%) | 2 (12.5%) |
| Maturation | 6 (13.3%) | 5 (17.2%) | 1 (6.3%) |
| Motor coordination | 6 (13.3%) | 5 (17.2%) | 1 (6.3%) |
| Psychological skills | 3 (6.7%) | 1 (3.4%) | 2 (12.5%) |
| Biomechanical features | 4 (8.9%) | 4 (13.8%) | 0 (0.0%) |
| **Task constraints** | | | |
| Quantity/quality of practice/training | 9 (20.0%) | 4 (13.8%) | 5 (31.3%) |
| **Environmental constraints** | | | |
| Sociocultural characteristics | 3 (6.7%) | 0 (0.0%) | 3 (18.8%) |
| Subjective coach evaluation | 6 (13.3%) | 2 (6.9%) | 4 (25.0%) |
| Multidimensional analysis | 16 (35.5%) | 10 (34.5%) | 5 (31.3%) |
| Sport performance | 20 (44.4%) | 9 (31.0%) | 11 (68.8%) |

Characteristics of individual studies included in the review are presented in Table 5. One hundred fifty-two talent indicators (either test or measurement) were identified, including anthropometric characteristics (*n* = 40), physiological characteristics (*n* = 50), technical skills (*n* = 16), tactical/perceptual cognitive skills (*n* = 13), maturation (*n* = 2), motor coordination (*n* = 3), psychological skills (*n* = 7), biomechanical features (*n* = 3), quantity/quality of practice/training (*n* = 5), sociocultural characteristics (*n* = 4), subjective coach evaluation (*n* = 1), and sport performance (*n* = 7). Moreover, 27 studies measured body mass, height (*n* = 26), handgrip strength, competition performance and subscapular skinfold (*n* = 13), circumference of calf and body fat (*n* = 12), triceps skinfold (*n* = 11), circumference of arm and Special Judo Fitness Test (*n* = 10), suprailiac skinfold, lean body mass and ranking (*n* = 9), circumference of forearm, abdominal skinfold, calf skinfold and lower limb explosive strength – CMJ (*n* = 8), body mass index, leg length, upper limb explosive strength – ball throw, dynamic strength – sit-up, time of practice, competitive level and video analysis (*n* = 7), upper limb dynamic strength – push-up and subjective coach evaluation (*n* = 5), flexibility – seat and reach, agility, 30 m speed, age at peak height velocity and static strength – judogi chin-up (*n* = 4), previous performance, anaerobic capacity – Wingate test, throwing technique (Nage-Waza), dynamic judogi chin-up (*n* = 3), motivation (*n* = 3), 20 m speed, family support, and eye-hand coordination, and fighting tactic (*n* = 2).

The following variables were found to discriminate skilled from less-skilled athletes: height (Detanico et al., 2021), body fat (Elipkhanov & Nemtsev, 2013), hand, arms and legs size (Elipkhanov & Nemtsev, 2013), muscle mass (Elipkhanov & Nemtsev, 2013; Fukuda et al., 2018), circumferences (Franchini et al., 2005, 2011; Štefanovský et al., 2017), anaerobic power (Franchini et al., 2005), static strength (Bonitch-Góngora et al., 2013; Detanico et al., 2021; Iermakov et

al., 2016; Krstulović et al., 2005), dynamic strength (Bonitch-Góngora et al., 2013; Krstulović et al., 2005), upper limb explosive power (Helm et al., 2018), aerobic capacity (Krstulović et al., 2005), jumping tasks (Detanico et al., 2021; Fukuda et al., 2018; Zaggelidis et al., 2012), Special Judo Fitness Test (Agostinho et al., 2018; Boguszewska et al., 2010; Franchini et al., 2005), technical skills (Zaggelidis et al., 2012), time-motion and technical-tactical variables (Miarka et al., 2014), force-time curve (Fukuda et al., 2018), maturation (Giudicelli et al., 2021), practice time (Detanico et al., 2021; Oliveira et al., 2006), and motivation (Oliveira et al., 2006).

Other variables were predictors of future performance, such as the general ability test (Lidor et al., 2009) or a combination of motor abilities (Caput et al., 2013; Krstulović et al., 2006; Wazir et al., 2017) , left-handedness (Sterkowicz et al., 2010), body fat (Nikolova & Dimitrova, 2018), handgrip strength (Kuvačić et al., 2017; Sánchez et al., 2011), reaction time (Lech et al., 2014), coordination (Kuvačić et al., 2017; Lech et al., 2014; Letts et al., 2007), speed (Lech et al., 2015), endurance (Kuvačić et al., 2017; Lech et al., 2015), jumping ability (Kuvačić et al., 2017), technical and tactical skills (Agostinho & Franchini, 2021), maturation (Detanico et al., 2020; Giudicelli et al., 2021), anaerobic power (Harris et al., 2020), strength and power in upper and lower limbs (Kons et al., 2020).

Additionally, some variables were associated with career progression and future success, such as the general ability test (Lidor et al., 2004), coordination and technical abilities (Osipov et al., 2017), senior performance (Barreiros et al., 2014; Julio et al., 2011; Massa, Uezu, Böhme, et al., 2010), family support (Massa et al., 2014; Massa, Uezu, & Böhme, 2010), pleasure and determination (Massa et al., 2014; Massa, Uezu, & Böhme, 2010), school competitive experience (Arantes et al., 2018), previous performance (Breviglieri et al., 2018).

**Table 5**
Characteristics of studies included in the review

| Authors | Study design | Sample/ country sex/age | Theme/ groups | Talent indicators | Summary results |
|---|---|---|---|---|---|
| Agostinho & Franchini (2021) | Cross-sectional | *N* = 296/NR female/male/ adolescent; adult | Performance prediction medalist vs. not medalist | Technical skills, tactical skills, competition performance | Higher variation was observed for gold medal winners for grip actions before the attack compared to bronze medalists, whereas transition variation was greater for gold medal winners compared to the other medalists. The variation in some elements can properly discriminate the podium position, females present less variation than males, but no relevant differences were found between age groups. |
| Agostinho et al. (2015) | Intervention short-tracking | *N* = 10/Brazil male/adolescent | Training effect age categories | Anthropometric characteristics, physical motor, technical skills, practice, competition performance | The best relationships between amounts of training and changes in performance were obtained when training amounts were quantified simply from rating of perceived exertion (RPE). RPE can predict more than 50% of the variance on performance changes in judo-specific tests (i.e., grip strength and endurance performance and number of throws during a high-intensity intermittent test). |
| Agostinho et al. (2018) | Cross-sectional | *N* = 266/ Brazil, Serbia, and Spain female/male/ adolescent | Group comparation cadet vs. junior | Anthropometric characteristics, physical motor, technical skills | Juniors performed better than cadets in the Special Judo Fitness Test as well as higher relative performance in the dynamic chin-up test. |
| Arantes et al. (2018) | Retrospective | *N* = 800/ Brazil female/male/ adolescent | Career pathway | Competition performance, coach's eye | 46.3% of medalists in Brazilian School Games, aged 12 to 14 years, were identified as talented athletes, between 2005 and 2010. 174 were judo athletes. Brazilian School Games has fulfilled an important role in the process of discovery and development of sports talent in Brazil. |
| Barreiros et al. (2014) | Retrospective | *N* = 395/Portugal female/male adolescent/ adult | Career pathway | Competition performance | Only 37.5% of pre-junior athletes were re-selected as juniors and 28.1% as seniors, confirming the difficulties of predicting late success based on early identification and selection. |
| Bliznevsky et al. (2016) | Intervention short-tracking | *N* = 124/Russia male/adolescent; adult | Training effect | Psychological skills, technical skills, tactical skills, practice, sociocultural characteristics | In youngsters categories judo athletes' attitude to sports functioning orientation for avoiding of failures prevail rather than orientation for success. With sportsmanship rising there appears a trend to weakening of orientation for training process and strengthening of orientation for competition functioning. In the process of formation of judo athletes' attitude to sports practicing it is necessary to consider initial level of training and competition motivation in them, as well as to strengthen attitude to competition functioning. |

| Authors | Study design | Sample/ country sex/age | Theme/ groups | Talent indicators | Summary results |
|---|---|---|---|---|---|
| Boguszewska et al. (2010) | Cross-sectional | *N* = 8/Poland male/adolescent | Correlation | Anthropometric characteristics, physical motor, biomechanical features, technical skills | Index of Special Judo Fitness Test correlated significantly with physical fitness. Training processes should use biomechanics measurements, physical fitness tests and special fitness tests. |
| Bonitch-Góngora et al. (2013) | Cross-sectional | *N* = 73/Portugal, Sweden, Denmark, and Spain female/male/ adolescent | Group comparation elite vs. not elite | Anthropometric characteristics, physical motor | Male and female elite judokas developed higher levels of relative isometric handgrip strength in the maximum test and during all contractions of the endurance test than non-elite judokas. |
| Breviglieri et al. (2018) | Retrospective | *N* = 1,734/NR female/male adolescent; adult | Performance prediction ranking | Competition performance | The Judo World Ranking List and short-term performance could partially predict World Championships performance for cadet, junior and senior male and female judo athletes (5% to 27%). |
| Caput et al. (2013) | Cross-sectional | *N* = 57/Croatia NR/adolescent | Performance prediction more skillful vs. less skilled | Anthropometric characteristics, physical motor, motor coordination, coach's eye | The best predictor of competition efficiency in young judoka was the factor which integrates explosive power, coordination, and muscle endurance. The second one was the factor of movement frequency. |
| Courel-Ibáñez et al. (2018) | Cross-sectional | *N* = 34/Spain male/adolescent | Group comparation age categories | Anthropometric characteristics, technical skills | Competitive level comparisons between under 15 years-old amateur and Spanish National Judo Team revealed no difference in Special Judo Fitness Test performance. The Special Judo Fitness Test index is not a proper variable to detect differences between groups at these ages. |
| Detanico et al. (2020) | Cross-sectional | *N* = 66/Brazil male/adolescent | Performance prediction | Anthropometric characteristics, physical motor, technical skills, practice, maturation | Estimated age-peak height velocity, and growth variables explained moderate to large proportions of the variance in neuromuscular tests (with exception of standing long jump test), while both estimated age-peak height velocity, training and growth variables were predictors of judo-specific performance. |
| Detanico et al. (2021) | Cross-sectional | *N* = 66/Brazil male/adolescent | Group comparation national vs. state level | Anthropometric characteristics, physical motor, technical skills, practice, maturation | Stature, judo experience, Judogi Grip Isometric Strength Test, and standing long jump test performance were higher in the national group and could adequately discriminate competitive levels. |

| Authors | Study design | Sample/ country sex/age | Theme/ groups | Talent indicators | Summary results |
|---|---|---|---|---|---|
| Elipkhanov & Nemtsev (2013) | Cross-sectional | *N* = 45/Russia female/adolescent; adult | Group comparation more skillful vs. less skilled | Anthropometric characteristics | Judoka with less body fat, more thoracic muscle mass, longer hands, and shorter arms and legs are more successful in female judo. |
| Franchini et al. (2005) | Cross-sectional | *N* = 126/ Brazil NR/adolescent; adult | Group comparation elite vs. not elite | Anthropometric characteristics physical motor technical skills | Elite group presented higher upper body (Wingate test) and specific anaerobic power and capacity (Special Judo Fitness Test) and higher circumferences (specially from upper body, indicating superior muscle mass in this area) than the non-elite group. Skinfold, hand grip strength, and aerobic power and capacity were similar in elite and non-elite judo players. |
| Franchini et al. (2011) | Cross-sectional | *N* = 87/Spain female/male/ adolescent | Group comparation cadet vs. junior vs. senior | Anthropometric characteristics | Morphologically high-level cadet judo athletes are quite similar to older athletes and coaches can select them from these ages. |
| Fukuda et al. (2018) | Cross-sectional | *N* = 26/NR female/male/ youth; adolescent | Group comparation age categories | Anthropometric characteristics, physical motor, biomechanical features, practice, maturation | Somatic maturity had the greatest relationship with handgrip performance and lower-body plyometric ability. Somatic maturity and training experience accounted for 72% of the variance in hopping power. Muscle morphology was best related to somatic maturity. Significant differences were found between child and adolescent judo athletes in force–time curve parameters, muscle morphology, and plyometric ability. |
| Giudicelli et al. (2020) | Cross-sectional | *N* = 67/Portugal male/youth | Performance prediction | Anthropometric characteristics, physical motor, maturation | The maturation effect remained on the aerobic capacity and handgrip strength. Fat mass and fat-free mass mediated the effect on aerobic capacity. Fat mass, fat-free mass, stature, arm span, and inferior members length totally mediated the effect on handgrip strength. |
| Giudicelli et al. (2021) | Cross-sectional | *N* = 67/Portugal male/youth | Group comparation | Anthropometric characteristics, physical motor, maturation | The maturation attenuated the age effect in most variables and significantly affected upper body and handgrip strength. Anthropometric variables attenuated age and maturity and those associated with body composition significantly affected the performance in most tests, suggesting the potential value of using bio-banding strategies. |
| Harris et al. (2020) | Retrospective | *N* = 25/India female/male/ adolescent | Performance prediction medalist vs. not medalist | Anthropometric characteristics, physical motor | Medalists demonstrated greater lower-body absolute and relative strength, and greater lower-body absolute and relative anaerobic power. Anaerobic power can correctly predict 76.5% and 62.5% of not medalists and medalists, respectively. |

| Authors | Study design | Sample/ country sex/age | Theme/ groups | Talent indicators | Summary results |
|---|---|---|---|---|---|
| Helm et al. (2018) | Cross-sectional | *N* = 41/NR male/adolescent; adult | Group comparation elite vs. sub-elite | Anthropometric characteristics, physical motor, biomechanical features, technical skills | Electromyographic activity of trunk and upper limb muscles were assessed separately for the lifting and pulling arm. Elite athletes showed mostly better mechanical work, maximal force, and power compared with sub-elite athletes. The judo ergometer system (JERGo©) was valid in discriminating athletes of different performance levels predominantly during kuzushi without tsukuri. |
| Iermakov et al. (2016) | Cross-sectional | *N* = 28/ Ukraine male/adult | Group comparation different martial arts | Anthropometric characteristics, physical motor | Demonstrated the importance of studying of grip strength as factor of martial arts sportsmen's success, specializing in throws and grips of immobilization of opponent's body. |
| Jagiełło et al. (2014) | Longitudinal | *N* = 39/ Poland female/adolescent; adult | Career pathway more skillful vs. less skilled | Anthropometric characteristics, physical motor, technical skills, competition performance, coach's eye | It is impossible to accurately predict the future sports performance on the basis morphofunctional traits of judo athletes. However, at particular stages of judo training it is possible determine the most dominant morphofunctional traits associated with efficiency during judo tournaments. |
| Julio et al. (2011) | Retrospective | *N* = 406/ Brazil female/male/ youth; adolescent; adult | Career pathway | Competition performance | Successful competitive performance in early judo competition was not associated with success later in adulthood. Only 7% of the male and 5% of the female athletes had maintained their competitive levels. |
| Kons et al. (2020) | Cross-sectional | *N* = 94/Brazil female/male/ adolescent | Performance prediction | Anthropometric characteristics, physical motor, technical skills | Strength and power in upper and lower limbs are related to judo-specific tasks in young judo athletes and can moderately predict the performance in Special Judo Fitness Test performance. |
| Krstulović et al. (2006) | Cross-sectional | *N* = 40/Croatia NR/adolescent | Performance prediction | Anthropometric characteristics, physical motor, motor coordination, competition performance | A combination of coordination/strength, speed, flexibility and balance (motor abilities) and above-average muscle mass, bone volume and skeleton longitudinality (morphological characteristics) or above-average endurance along with moderate coordination/ strength and speed, and below-average muscle mass and bone volume and above-average skeleton longitudinally upon judo performance as expressed by the fight winning score. |
| Krstulović et al. (2005) | Cross-sectional | *N* = 34/Croatia female/adolescent | Group comparation successful vs. less successful | Anthropometric characteristics physical motor technical skills | Successful judoists presented higher dynamic and static strength (chest and arm strength push-up test, static strength endurance bent arm hang test) and endurance performance (aerobic endurance 6 min running test). No significant differences in the anthropometric dimensions were found. |

| Authors | Study design | Sample/ country sex/age | Theme/ groups | Talent indicators | Summary results |
|---|---|---|---|---|---|
| Kuvačić et al. (2017) | Cross-sectional | *N* = 111/Croatia female/male/adolescent | Performance prediction competition vs. expert opinion | Anthropometric characteristics, physical motor, motor coordination, technical skills, competition performance, coach's eye | Maximum strength, coordination, jumping ability, speed, agility, muscular endurance, and specific endurance were common determinants of success. Factors of success differed with regard to weight categories. Maximum strength played the most vital role. |
| Lech et al. (2014) | Cross-sectional | *N* = 8/Poland male/adolescent | Performance prediction more skillful vs. less skilled | Anthropometric characteristics, physical motor, motor coordination, technical skills, tactical skills, competition performance | High levels of adaptive ability were prerequisites for high levels of activity during phase I of a bout. Shorter durations of complex reaction time were correlated with higher effectiveness in both the phase I and throughout a bout. High levels of visual-motor coordination were correlated with high effectiveness and its increase during phase II of a bout. However, they do not correlate directly with the level of achievement. |
| Lech et al. (2015) | Cross-sectional | *N* = 25/ Poland NR/adolescent; adult | Performance prediction cadet vs. junior vs. senior | Anthropometric characteristics, physical motor, motor coordination, technical skills, biomechanical features, competition performance | In the senior group, high coordination abilities level was connected with contestants high activity in the second phase of the fight. The elevated activity was determined by coordination, speed and endurance abilities. High speed abilities in juniors was directly connected with their sports achievements. |
| Lidor et al. (2004) | Longitudinal | *N* = 10/Israel male/adolescent | Career pathway, ranking | Anthropometric characteristics, physical motor, technical skills, coach's eye | Specific judo ability test (10 station test) did not correlate with ranking made by national coaches in the early phases of talent development or eight years after the training program. The 3 min general ability test (sit-ups, push-ups, and side-to-side jumping) was a good predictor of actual and future ranking. Rankings made by coaches had high intra-class correlation. |
| Massa, Uezu, Böhme, et al. (2010) | Retrospective | *N* = 6/Brazil male/adult | Career pathway | Competition performance | Most of the athletes analyzed (83.3%) were not young talents. Selecting athletes precociously is a risk to the talent development process. |
| Massa et al. (2014) | Retrospective | *N* = 6/Brazil male/NR | Career pathway | Practice, sociocultural characteristics | The early training is one of the most relevant factors for the acquisition of a high level of performance subsequent to the time that the average age of initiation into the sport occurred at around 6.2 ± 1.3 years. Family support combined with a microsystem development of athletes, form an environment capable of generating international level judo athletes. |

| Authors | Study design | Sample/ country sex/age | Theme/ groups | Talent indicators | Summary results |
|---|---|---|---|---|---|
| Massa, Uezu, & Böhme (2010) | Retrospective | *N* = 6/Brazil male/adult | Career pathway | Psychological skills, sociocultural characteristics | The speeches pointed out the factor's family support, pleasure in the practice and the athlete's determination for the development of talents in several domains of knowledge as important for the psychosocial support in the development of talented Brazilian male judokas. |
| Miarka et al. (2014) | Cross-sectional | *N* = 717/ Brazil female/adolescent; adult | Group comparation pre-cadet vs. cadet vs. junior vs. senior | Technical skills, tactical skills, competition performance | Time-motion and technical–tactical variables were different in female judo athletes between age groups. Senior age group presented higher values of total combat time, standing combat time and gripping time than all other groups. Prescription of training for pre-cadet, cadet and junior female judo athletes should consider the specific demands of the competitive match, with maturation being considered as an indicator of performance capacity. |
| Nikolova & Dimitrova (2018) | Cross-sectional | *N* = 74/Bulgaria female/male/ adolescent | Performance prediction medalist vs. not medalist | Anthropometric characteristics | Medal winners from both sexes had lower body fat as compared to non-medalists. Male judokas with higher athletic achievements were significantly taller and had a larger arm span than their counterparts who are non-medalists. |
| Oliveira et al. (2006) | Cross-sectional | *N* = 52/Brazil male/adolescent; adult | Group comparation selected vs. not selected | Psychological skills, practice, competition performance | Selected athletes were older, presented increased practice time, performance level and competitive tendencies of winning and setting goals than non-selected judokas. |
| Osipov et al. (2017) | Longitudinal | *N* = 60/Russia male/adolescent; adult | Career pathway more skillful vs. less skilled | Physical motor, technical skills, tactical skills, competition performance, coach's eye | The level of some boys' physical superiority over their peers as on the moment of selection to judo schools cannot be an objective criterion of significant sports results' achievements. |
| Prieske et al. (2020) | Longitudinal | *N* = 44/Germany female/male/ adolescent | Career pathway | Anthropometric characteristics, physical motor, technical skills, practice, maturation, competition performance | The non-significant, small-to-moderate-sized correlations were identified between changes in anthropometry/body composition/ physical fitness and sporting success. Ten months of judo training and/or growth/maturation contributed to significant changes in anthropometry, body composition, and physical fitness, particularly in young male judo athletes. |
| Sánchez et al. (2011) | Cross-sectional | *N* = 102/ Spain female/male/ adolescent | Performance prediction medalist vs. not medalist | Physical motor, competition performance | Athletes pertaining to heavier weight classes presented greater levels of strength. Handgrip strength was an indicator for predicting the results of competitions, but only for female athletes. |

| Authors | Study design | Sample/ country sex/age | Theme/ groups | Talent indicators | Summary results |
|---|---|---|---|---|---|
| Štefanovský et al. (2017) | Cross-sectional | *N* = 47/Croatia, Ukraine, Slovenia, Hungary, Poland, Austria, Czech, and Slovak Republic male/adolescent; adult | Group comparation cadet vs. junior vs. senior elite vs. not elite | Anthropometric characteristics | Forearm and wrist circumference are a reliable discriminative factor and should be taken into consideration, especially when selecting judo athletes into elite teams. |
| Sterkowicz et al. (2010) | Cross-sectional | *N* = 90/ Poland Male/Adolescent | Performance prediction medalist vs. not medalist | Technical skills, competition performance | Laterality of upper and lower limbs shows significant correlation with the choice of dominant directions of a tack in fight. Left-sided athletes show significantly better chances of winning medals compared to their right-sided counterparts. |
| Wazir et al. (2017) | Retrospective | *N* = 22/Belgium male/adolescent | Performance prediction elite vs. sub-elite vs. dropout | Anthropometric characteristics, physical motor, motor coordination, competition performance | Elite group performed better than the sub-elites and drop outs in most of the physical performances test (5 m sprint test, 30 m sprint test, sit and reach test, sit up test and beep test). Generic test battery provides opportunities for predicting judo performance of young athletes. |
| Zaggelidis et al. (2012) | Cross-sectional | *N* = 20/ Greece male/adolescent; adult | Group comparation athlete vs. not athlete | Physical motor | Advanced young judokas presented higher scores in all examined jumping tasks (squat jumps, countermovement jumps and drop jumps from 20 and 40 cm height) compared to untrained ones. |
| Zeghari et al. (2019) | Intervention short-tracking | *N* = 12/ Morocco male/youth | Training effect | Anthropometric characteristics, physical motor, technical skills, practice | The 12-week training program developed resulted in an evolution in speed in the 10 m test and in the Uchi Komi test. |

## Discussion

The aim of this article was to review the available literature on talent identification and development in judo. The results showed an incremental interest in this research topic, especially between the years 2014 and 2021, with high quality of evidence. Overall, the majority of the studies used cross-sectional designs with group comparisons or performance prediction. Batteries of tests were applied on expert or advanced samples and measured individual constraints, especially anthropometric and physiological characteristics and technical skills. Performance in competition was examined in half of the studies. Few studies examined female samples, psychological skills, biological maturation and/or used multivariate statistical analyses. Considering the results based on an ecological dynamics theoretical framework, there was a high degree of variability in the indicators that were found to discriminate between skilled and less-skilled judo athletes, and/or to predict performance or career pathways. In the following sections some of the most interesting results of this review will be discussed.

### Talent and its relevance for athlete development

Every young person has a sporting potential that can be further developed, but few have high potential to become experts in the future. Identifying sporting talent is a complex task, since there is no consensus on its definition (Baker et al., 2019; Johnston & Baker, 2022). In this review, the criterion used to define talent was the ranking, selection or performance of athletes in state or national championships (Arantes et al., 2018), differences between elite and non-elite athletes (Franchini et al., 2005) or a combination of motor, technical and psychological abilities (Osipov et al., 2017). From this perspective, talent is a pre-requisite for high performance, but it is not a sufficient condition. Combat sports coaches define talent as the potential for elite performance in the future and believe that identifying the right athlete at the right time is possible, dynamic and important to ensure that the best athletes are developed, preventing the loss of talent in the sport (Roberts et al., 2021).

To provide a working framework, Baker et al. (2020) proposed a multi-faceted conceptualization of talent as innate (originating in biological elements present at birth), multidimensional (consisting of capacities from a range of broad cognitive, physical, and psychological categories), emergency (the result of diverse multiplicative processes), dynamic (its expression evolves over time due to interactions with the environment), and symbiotic (subject to environmental constraints). This framework has implications for understanding the continuum of performance from novice to expert (Baker et al., 2015). Unfortunately, few studies in judo have examined elements of athlete development frameworks (Barreiros et al., 2014; Massa et al., 2014; Massa, Uezu, & Böhme, 2010; Massa, Uezu, Böhme, et al., 2010), instead usually focusing simply of between group comparisons.

Based on this review, early specialization in judo was not associated with success during adulthood, and programs directed to talent selection and promotion should focus on other aspects than the competitive result (Julio et al., 2011). Most Olympic Brazilian judo athletes were not precocious talents, but identified and developed in a long-term training process (Massa, Uezu, Böhme, et al., 2010). Juvenile or junior performance was not a guarantee of senior success (Barreiros et al., 2014; Julio et al., 2011; Massa, Uezu, Böhme, et al., 2010). Deliberate practice explains some of the performance, but other factors such as the opportunity to train, family support, date of birth, place of birth, basic abilities, personality, starting age, and genetic factors are also likely important (Hambrick et al., 2016). Based on a Danish sample of elite and near-elite athletes, the key to success in centimeters, grams, or seconds (cgs) sports was to specialize at a later age, to train less in childhood, and to intensify the training during late adolescence (Moesch et al., 2011).

Thus, factors related to the organization of practice during childhood and adolescence are crucial for future success. Talent development programs should prioritize the participation and maintenance of

selected and unselected subjects, offering development opportunities to as many young people as possible. The process of development should be done holistically to maximize the chances of young people remaining engaged in sports. Besides, maximizing sporting talent, reduce the risk of sport-related injury, and to ensure long-term health and well-being are important goals of long-term athletic development models (Lloyd et al., 2015). Future research should adopt a longitudinal design to draw causal inferences. Scientific evidence on sporting talent does not result from individual cases, but from the identification of patterns of indicators of sporting potential and performance (Güllich et al., 2022). These assumptions need to be investigated in judo.

## How to identify talents: Battery of tests or coaches' eye? Both!

The assessment of sporting potential is the first step in the process of discovering new talents and it should be understood as inclusive and holistic process (Till & Baker, 2020). Our results showed that a battery of tests is the most common method used for talent identification and selection in judo. There is a consensus in the scientific literature on the value of generic and sport-specific battery of tests as the assessment of athletes' strengths and weaknesses, to create norms and criteria for young elite athletes, to plan the training program, to monitor how athletes developed over time, and motivate to attain greater achievements (Issurin, 2017; Johnston & Baker, 2020; Lidor et al., 2009; Till & Baker, 2020). However, their validity in predicting future performance and discriminating skill levels is limited.

Studies on talent identification, talent selection and competition performance are beginning to fulfil the call for interdisciplinary and multidisciplinary research, especially in sports like soccer, field hockey, Australian football, handball and rugby (Piggott et al., 2019). However, this review found only one study that examined simultaneous individual, task, and environmental constraints in judo (Bliznevsky et al., 2016). Instead, the talent indicators most evaluated in the articles were anthropometric (66.0%), physiological (59.6%) and technical (46.8%) characteristics. In every sport in which success is determined by the body type and human physical characteristics, monitoring of morpho functional traits may have value for effective selection of candidates and management of the training process (Jagiełło et al., 2014). However, it is difficult to recommend one particular test to be used by coaches in their search for talent (Lidor et al., 2004) since judo is categorized by physical abilities such as explosive strength, speed and coordination as well as technical skill (Zaggelidis et al., 2012). For instance, dynamic-strength-endurance allows one to efficiently perform the specific dynamic judo patterns and tasks, while static strength endurance ensures the effectiveness of the gripping techniques. Given that judo tournaments and competitions are exceptionally time concentrated, aerobic-endurance may affect recovery, allowing an athlete to perform repeatedly at a high level of efficacy (Krstulović et al., 2005).

In this context, a non-sport-specific generic testing battery has been shown to distinguish youth judo athletes from athletes in other sports. Dynamic strength, speed and agility, for example, were discriminating characteristics to judo (Chaabene et al., 2018; Pion et al., 2014). Moreover, generic talent characteristics (anthropometry and physical qualities) were able to successfully discriminate between drop out, sub-elite and elite judo athletes (Wazir et al., 2017) as well as to predict actual and future judo performance of young athletes (Lidor et al., 2004). In general, generic tests may have some value in assessing sporting potential, as well as, perhaps more importantly, guiding young individuals to modalities (e.g., judo) that best suit their profile and monitoring the effects of training in a systematic and longitudinal approach to development (Miranda et al., 2019; Wazir et al., 2017).

With this in mind, and based on the results of this review, some recommendations for coaches, especially, in early stages of athlete development in judo are necessary. First, tests measure actual performance or athletes' characteristics, and this information can be used to augment feedback to athletes and their coaches.

However, due to the greater biological variability observed in adolescence, and the range of variation of anthropometric and physiological indicators observed in this period, caution is recommended in the early selection of athletes. During puberty, boys may show increases of up to 20% in height and agility, and 40% in body mass, in addition to a 50% decrease in fat percentage and gains of up to 50% in anaerobic power and 70% in aerobic endurance (Pearson et al., 2006). Besides, motor talent diagnosis considering the 98$^{th}$ percentile in strength, speed or aerobic resistance tests shows low stability nine months after assessment (Miranda et al., 2019). In judo athletes, estimated age-peak height velocity (PHV) and growth variables explained moderate to large proportions of the variance in neuromuscular tests, and in combination with training were predictors of judo-specific performance (Detanico et al., 2020). Other studies have considered the importance of biological maturation and its effects on the morphology and neuromuscular performance of young judo athletes (Fukuda et al., 2018; Giudicelli et al., 2020), as well as discriminating between judo athletes of different competitive levels (Detanico et al., 2020).

Second, before peak height velocity, athlete selection should be related to performance of motor skills (coordination), with physical fitness (strength, agility, speed, and endurance) considered after this period (Fransen & Güllich, 2019). Coordination is a valuable indicator of athletes' potential or progression and as such, it is an important talent characteristic in skill-based sports like combat sports (Sadowski, 2005). Some studies have used this assessment in judo athletes (Caput et al., 2013; Krstulović et al., 2006; Lech et al., 2014, 2015; Wazir et al., 2017). In addition to predictive ability, tests of motor coordination and technical skills are less influenced by biological maturation (O'Brien-Smith et al., 2019; Pearson et al., 2006). Osipov et al. (2017) emphasize the physical superiority of some young people over others, at the time of sports selection, should not be used as an objective criterion for future sports results, rather the level of coordination and the ability to quickly master judo techniques should be weighted more heavily.

Third, it is recommended that talent predictors be systematically assessed over time, emphasizing individual development and the need for assessment using tasks that are representative of the skills needed in competition (i.e., high in ecological validity). In this review, almost half of the studies measured technical skills. However, in Olympic combat sports, the applicability, generality, and accuracy of outcomes of sport-specific testing present several methodological gaps (Chaabene et al., 2018). Thus, some judo specific tests, like the Special Fitness Judo Test, deserve further scientific exploration and should be used with caution if being implemented for the sake of discriminating skill levels (Courel-Ibáñez et al., 2018; Franchini et al., 2005). Boguszewska et al. (2010) suggest the combination of different methods in the assessment of the athlete's potential and in the training process. Future studies should investigate the use of open-ended skills tests, especially if combined with the coach's opinion.

A fourth recommendation is that batteries of tests should not replace the subjectivity of the coach in decision making for the identification and development of promising young prospects. Studies suggest coaches use their gut feeling, based on objective and subjective information acquired throughout their career to make decisions during the process of talent identification, selection, and development (Roberts et al., 2019). The coach's eye may be useful in identifying talent for two main reasons: a) there are certain characteristics of sports talent that are difficult to observe and measure, except through the eyes of the specialist; b) unlike tests, which measure current performance, coaches are able to estimate the athlete's development potential and the chance of success in the future (Werneck et al., 2020). In the articles included in this review, coaches participated in the research in different ways: evaluation of the performance of athletes in competition (Caput et al., 2013; Osipov et al., 2017; Werneck et al., 2020), ranking of athletes (Jagiełło et al., 2014; Lidor et al., 2004), definition of criteria for talent (Arantes et al., 2018) and opinion on the impor-

tance of different indicators for performance (Kuvačić et al., 2017), in addition to predicting future success (Lidor et al., 2004; Osipov et al., 2017). A recent study conducted with athletes, coaches, directors and experts from 11 different countries revealed that the identification and development of talent is one of the pillars of international sporting success in judo, along with other contextual factors (Mazzei et al., 2021). Thus, batteries of tests and the coaches' view are not divergent assessments, but complementary. The identification of talented athletes in judo should combine scientific knowledge with the practical experience of coaches within a longitudinal and dynamic process, emphasizing the development of talented judo athletes rather than the process of early talent identification.

## Skilled and less-skilled judo athletes, performance and career pathway predictions

This review suggests very little is known about the indicators that discriminate highly skilled from lesser skilled judo athletes or that predict current performance or future success. In group-comparison studies, anthropometrics (Courel-Ibáñez et al., 2018; Detanico et al., 2021; Elipkhanov & Nemtsev, 2013; Fukuda et al., 2018; Helm et al., 2018; Štefanovský et al., 2017), physical motor (Agostinho et al., 2018; Detanico et al., 2021; Fukuda et al., 2018; Iermakov et al., 2016; Krstulović et al., 2005), biomechanical (Fukuda et al., 2018; Helm et al., 2018), psychological skills (Oliveira et al., 2006), technical skills (Agostinho et al., 2018; Detanico et al., 2021; Franchini et al., 2005; Helm et al., 2018; Miarka et al., 2014), tactical skills (Miarka et al., 2014), quantity and quality of practice (Oliveira et al., 2006), sociocultural characteristics (Fukuda, 2015), and maturation (Fukuda et al., 2018) were discriminators of athletes' skill levels. However, these findings were not always consistent: other studies did not find skill level differences in anthropometrics (Agostinho et al., 2018; Franchini et al., 2011; Iermakov et al., 2016), physical motor (Bonitch-Góngora et al., 2013), technical skills (Courel-Ibáñez et al., 2018; Krstulović et al., 2005).

With regards to predicting performance in judo, handgrip strength appears to be a consistent predictor (Bonitch-Góngora et al., 2013; Giudicelli et al., 2021; Iermakov et al., 2016; Kuvačić et al., 2017; Sánchez et al., 2011), but it is necessary to consider the effects of biological maturation (Detanico et al., 2020) in order to avoid selection bias towards early maturers. Other predictors of performance included: anthropometrics agostinho et al. 2015 (Agostinho et al., 2015; Agostinho & Franchini, 2021; Krstulović et al., 2006; Nikolova & Dimitrova, 2018), physical motor (Caput et al., 2013; Krstulović et al., 2006; Kuvačić et al., 2017; Lech et al., 2015; Sánchez et al., 2011; Wazir et al., 2017), technical skills (Kuvačić et al., 2017; Sterkowicz et al., 2010), competition performance (Breviglieri et al., 2018), motor coordination (Krstulović et al., 2006; Kuvačić et al., 2017; Lech et al., 2014, 2015; Zeghari et al., 2019) and subjective coach evaluation (Caput et al., 2013). Once again, there were some mixed results: in other studies anthropometrics (Harris et al., 2020; Kons et al., 2020; Kuvačić et al., 2017; Lech et al., 2015), physical motor (Harris et al., 2020), biomechanical (Lech et al., 2015), technical skills (Lech et al., 2014) and motor coordination (Wazir et al., 2017) were not able to predict the performance of judo athletes.

Some indicators such as anthropometrics (Jagiełło et al., 2014; Prieske et al., 2020), general skill test (Jagiełło et al., 2014; Lidor et al., 2004; Prieske et al., 2020), or a combination of motor skills (Caput et al., 2013; Krstulović et al., 2006; Wazir et al., 2017), psychological skills (Massa, Uezu, & Böhme, 2010), technical skills (Jagiełło et al., 2014; Osipov et al., 2017), quantity and quality of practice (Massa et al., 2014), performance in competition (Barreiros et al., 2014; Jagiełło et al., 2014; Massa et al., 2014), and sociocultural characteristics (Massa et al., 2014; Massa, Uezu, & Böhme, 2010) have been pointed out as predictors of future success. However, in other studies, anthropometric (Lidor et al., 2004), physical motor (Osipov et al., 2017), technical skills (Lidor et al., 2004), and competitive performance (Julio et al., 2011; Massa, Uezu, Böhme, et al., 2010) were not predictors. Retrospective studies carried out with athletes who

achieved success allow us to identify patterns in the sports career of these athletes that might help the talent identification as well as the talent development process (Julio et al., 2011; Massa et al., 2014; Massa, Uezu, & Böhme, 2010). However, these studies do not allow us to know if athletes who did not achieve success also had the same characteristics as the successful ones, such as family support, determination, etc. Data from longitudinal studies provide a higher standard of evidence and, therefore, should be classified as more meaningful than cross-sectional data. Notably, in the case of female athletes, these longitudinal data are particularly lacking.

A recent meta-analysis concluded that elite, world-class athletes had a diverse sports practice during childhood and adolescence, specialized later, and progressed more slowly when compared to national-level athletes (Güllich et al., 2022). Judo is an early initiation sport and those who continue in the training process benefit from longer practice (i.e., development) time to acquire greater expertise (Massa et al., 2014). However, the early selection of athletes is a risk for the talent development process (Massa, Uezu, Böhme, et al., 2010), as early performance in judo is not associated with future senior success (Julio et al., 2011), reinforcing the problems of attempting to predict success through early identification and selection (Barreiros et al., 2014). Accurately predicting future sports performance, even on the basis of a number of systematically monitored multidimensional indicators of judo athletes at each stage of training, is a very imprecise task. The longer the time horizon between selection and eventual adult performance, the lower the accuracy in predictions about young athletes' potential (Jagiełło et al., 2014).

## Future research directions

In the field of sporting talent, there are more questions than answers, making this area a fertile field for further studies. Clarifying the most effective way to identify, select and develop sporting talent remains a central problem for researchers and coaches (Till & Baker, 2020). This systematic review was important for highlighting key areas of future research. For instance, most research on TID in judo lacks a theoretical model regarding the concept of sporting talent and its development. This result reflects the need for sport-specific approaches to talent, due to the lack of consensus on what talent is and what it means (Baker et al., 2019).

Understanding what facilitates engagement and effectiveness in sport can contribute to the development and implementation of effective programs. From the perspective of dynamic systems theory, we need to investigate the interaction of indicators related to the individual (genetics, ability, skills, psychological traits), environment (practice, training, social support, coaches) and the type of sport (Baker et al., 2020; Fransen & Güllich, 2019; Rees et al., 2016). Perhaps unsurprisingly, no studies with genetic indicators were found. The consensus statements from IOC do not recommend using genetic testing in talent identification and development (Bergeron et al., 2015). However, as differences in our genes explain some of the variation in the individual response to training, then a genetic test may help us identify those athletes that possess such genes which enable the greatest improvements from training (Pickering & Kiely, 2017). Talent identification programs often identify youngsters who are currently already very good at their sport as opposed to those with the greatest margin for improvement. Genetic methods will become increasingly available and translated into practical tools for sport scientists who will need to capitalize on such findings in an ethically acceptable manner (Pitsiladis & Wang, 2015). There is a long way to go in relation to genetic indicators of talent, configuring a promising area for future studies, like in judo.

Multidisciplinary and longitudinal research designs that emphasize the interactions between individual, task and environment constraints are necessary, such as the ecological dynamics model (Phillips et al., 2010). While many studies used test batteries, these tended to focus on physical and anthropometric variables, and therefore may have been limited by the absence of important psychological factors and maturational indicators. Therefore, the interaction between

biological maturation, psychological skills and other elements of performance should be investigated in future studies. Moreover, system constraints likely influence selection, development and participation, such as those reflected in the relative age effects (RAE). The RAE in judo seems to be evident in junior and medalist categories, especially in men (Fukuda, 2015; Lucena et al., 2013). However, the RAE is not consistently found in Olympic combat sports athletes, varying according to gender, modality and edition of the Olympic Games, and an inverse RAE has been observed (Campideli et al., 2018). Thus, new studies are needed to investigate the predictive capacity of RAE on the future success of judo athletes.

In order to optimally assess sporting potential and select athletes for higher levels of performance, scientific knowledge (test batteries) and the knowledge of the coaches (coach's eye) should be combined, possibly through computational statistical analysis procedures, to reflect a more comprehensive interdisciplinary and longitudinal perspective (Piggott et al., 2019; Ribeiro Junior et al., 2019, 2021). Researchers have used data science, which combines sports science, statistics, computer science and information technology within an innovation context (Ofoghi et al., 2013). For example, a simple linear equation that combines different variables and their respective weights can be effective for modeling the sporting potential of a young athlete (Johnston & Baker, 2020). In addition, further studies should evaluate the sport's potential dynamics, that is, how it evolves throughout the training process. Such designs may help increase the chance of finding variables that hold predictive utility for elite-level athletes (Abbott et al., 2005).

Researchers are also encouraged to devote greater attention to female athletes to better understand factors related to female-specific talent development. If we know very little about predictors of talent in judo, we know even less about predicting talent in female judo athletes. Relatedly, it was surprising that most studies in this review were from Brazil, Poland and Croatia. This emphasizes the need for more geographical diversity, particularly from countries that have different approaches to athlete selection and development. Finally, only one study was found with young school-level athletes. In Brazil, the School Olympics have played an important role in the process of discovering and developing talents in judo (Arantes et al., 2018). In light of this finding, greater attention should be given to exploring developing talents, including judo, within school-level athletes.

### Limitations of the review

Although this systematic review provides the first comprehensive synthesis of talent identification and development in judo, it is not without limitations. One limitation lies in the restriction imposed on articles written in English and Portuguese published in peer-reviewed journals. For instance, the greater number of articles published in Brazil may be due to some form of inclusion bias. Furthermore, many studies on combat sports are published in non-indexed journals (i.e., gray literature; Chaabene et al., 2018). As a result, there may be important findings and/or trends not captured in our review. Comparison studies between sexes and between weight categories were also not considered. Besides, future reviews may consider incorporating studies with coaches and experts in judo to expand our understanding of the process of talent identification and athlete development. Ultimately, these limitations suggest the profile of research provided in this review may present an imperfect picture of athlete development in judo.

## Conclusion

Findings from this review highlight the high-quality research on athlete identification and development in judo, with many positive implications for coaches and athletes. As reflected in other sports, most research focused on individual constraints related to anthropometric and physiological characteristics and technical skills, using cross-sectional designs. Despite the impressive amount of research done on judo, significant gaps in our understanding remain and future work is needed to fill these gaps. For instance, athlete iden-

tification processes in judo generally use batteries of tests to discriminate between skill levels, but talent selectors should proceed with caution when using physical tests (anthropometric and physiological measures) as the evidence for their validity in predicting future performance and discriminating skill levels is limited. Future research should focus on multidimensional and dynamical approaches of sporting talent and career progression of the most talented judo athletes, especially in female samples, and integrate existing findings about the maturational, psychological and environmental aspects of judo.

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## Acknowledgements

This review was registered at http://www.crd.york.ac.uk/prospero as CRD42021238166.

### Funding

Aline Aparecida de Souza Ribeiro was financed in part with the BSc scholarship by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

### Competing interests

Aline Aparecida de Souza Ribeiro, Francisco Zacaron Werneck, João Guilherme Vieira, Leandro Sant'Ana, Kathryn Johnston, Joseph Baker, and Jeferson Macedo Vianna declare that they have no conflicts of interest relevant to the content of this review.

No financial assistance was obtained for this study. The authors have no conflict of interests.

### Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

The data that support the findings of this study are available from the corresponding author upon reasonable request.