Assessment of Isokinetic Strength of Knee Extension/Flexion of Individuals With Intellectual Developmental Disabilities–Systematic Review With Protocol Proposal

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ABSTRACT

Muscle performance is a crucial determinant of physical function in the daily lives of individuals with intellectual developmental disabilities (IDD), with lower strength levels often leading to loss of independence. The isokinetic dynamometer has been established as a reliable method for assessing muscle performance in this population. This article outlines the design of a protocol to be adopted to assess isokinetic knee strength in individuals with IDD. Using systematic review methodology, electronic searches were conducted in PubMed, Scopus, SPORTDiscus, and Web of Science databases, including articles published between January 1990 and September 2022. The key terms were combined with the Boolean operator "AND" or "OR". After the methodological process, 23 studies were included for analysis. The protocol proposal consists of 8 phases, covering previous considerations: (a) warm-up, (b) familiarization; (c) equipment adjustment, choosing the limb to evaluate and in what type of action (concentric and/or eccentric); (d) number of repetitions and sets; (e) the rest duration; (f) angular velocity to be tested; and (g) parameters for analysis. It is intended that this article provide insights into the development of a useful tool for the various stakeholders interested in assessing the isokinetic knee strength of individuals with IDD.

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KEY WORDS:
concentric; dynamometer; eccentric; intellectual disability; knee extension; knee flexion; neuromuscular capacity

INTRODUCTION

Strength has been defined as "the ability of a muscle group to produce maximal contractile force against resistance in a single contraction, and is associated with the ability to perform activities that require high levels of muscular force" (2). The amount of force generated by muscle depends on the type of muscle contraction (concentric, isometric, or eccentric). Activities of daily living (ADLs) and athletics often require dynamic muscle contractions (33). Measuring muscle function using the isokinetic dynamometer is common for the general population (20). This test measures the torque developed at an isolated joint exercise, in which resistance is provided during constant angular velocity (49). This technique can be used to assess strength in agonist and antagonist muscle groups (ex. hamstrings and quadriceps) (49), usually determining the conventional ratio, obtained by dividing the maximal flexors moment by the maximal extensors moment measured at the same angular velocity, both performing at concentric action (1). This allows the characterization of muscle performance and the risk of injury through opposing muscle groups (54).

Dynamometry has been recognized as a viable method for assessing muscle performance in healthy and symptomatic populations (24,28), which involves constant angular velocity. Isokinetic muscle action can be defined as a type of muscle contraction in which the muscle shortens or lengthens at a constant velocity. Resistance is electronically controlled by a computer connected to the equipment, which exerts a resistance proportional to the torque developed by the individual and allows the assessment of muscle performance in dynamic conditions (6), both concentric or eccentric. This method has been used to study different phases of an exercise (10), determine differences in force production between various sports (35) or the effect of a physical exercise program (9), and is a common method for measuring muscle performance (35).

In individuals with intellectual developmental disabilities (IDD), characterized by deficits in general mental abilities and impairment in everyday adaptive functioning, with onset during the developmental period (3), measuring isokinetic strength using a dynamometer proved to be a reliable method (43). This technique constitutes an innovative method to measure physical fitness, essential in activities, tasks, and/or daily life routines, such as climbing stairs, walking, and transitioning between sitting and standing, among others (50). In addition, isokinetic testing is safe for this population because it allows controlled movement and range of motion, adjustable resistance based on the user's capabilities, and controls resistance for a single joint exercise.

Flexion and extension strength of the knee plays an important role in supporting body weight and supporting, aiding, and absorbing impact in various motor activities (walking and running, among others) and, therefore, can help predict functional ability (25,27,34). In turn, the functional capacity of individuals with IDD is fundamental for performing activities of daily living (44), such as climbing stairs, getting up, sitting, walking or running, and, consequently, improving their quality of life (7). It is also associated with increased autonomy and lessens dependence on others.

Considering that the isokinetic strength test is reliable for individuals with IDD (43) and recommended (2), this study aims to conduct a discussion of the manuscripts that have used this methodology in recent years and to present a suggested method to be adopted to assess knee extension/flexion isokinetic strength in this population.

METHODOLOGY

This systematic review was prepared following the items of the PRISMA guidelines (39). The PICOS strategy (36) was defined as follows: (a) "P" (Patients) corresponded to participants with IDD (including Down syndrome), of any age, gender, ethnicity, or race; (b) "I" (Intervention) nonapplicable; (c) "C" (Comparison) nonapplicable; (d) "O" (Outcome) corresponded to isokinetic strength as a primary or secondary variable in the study; (e) "S" (Study Design) corresponded to intervention studies, randomized controlled trials (RCTs) or non-RCTs, pilot study or cross-sectional studies. The protocol was registered in the PROSPERO, with the number CRD42022307164.

SOURCES OF INFORMATION AND RESEARCH STRATEGIES

The research was carried out until September 6, 2022, in English, by searching the databases PubMed (title and abstract), Web of Science, Scopus, and SPORTDiscus (title, abstract, and keywords), considering the period of retreat until 1990. The following descriptors were used: "dynamometer," "peak torque," "knee extensors," "knee flexors," "Intellectual Developmental Disorder," "intellectual disability," "intellectual disabilities," "mental retardation," "Down Syndrome," and "Down's syndrome," combined with the Boolean operator "AND" or "OR," as shown in Table 1.

DATA EXTRACTION PROCESS

The research was carried out by 2 investigators independently. After the process was concluded, duplicate articles and those not meeting the eligibility criteria were eliminated. After reading the full text of the article and using the eligibility criteria previously defined, the study sample consisted of 23 articles. One of the researchers downloaded the relevant information from the articles and entered it in Table 2 (author, year of publication, country, aims, participants, and assessment instruments).

ELIGIBILITY CRITERIA

For the selection of studies, the following inclusion criteria were considered: (a) intervention studies, RCT or non RCT, pilot, and cross-sectional studies; (b) individuals with IDD, including Down syndrome; (c) studies with individuals of any age group, gender, race, or ethnicity; and (d) studies that evaluated the muscle performance of the

Table 1
Research strategy

Research number	Research terms
1	("dynamometer" OR "peak torque" OR "knee extensors" OR "knee flexors") AND ("Intellectual Developmental Disorder" OR "intellectual disability" OR "intellectual disabilities" OR "mental retardation" OR "Down Syndrome" OR "Down's syndrome")

knee, through the isokinetic dynamometer. Likewise, the following exclusion criteria were considered: (a) studies that have not been published in English or Portuguese; (b) studies with participants with other pathologies and/or other disabilities; (c) studies that do not describe the evaluation protocol.

METHODOLOGICAL QUALITY ASSESSMENT

The methodological quality assessment process of the included articles was carried out independently by 2 authors and any disagreements were resolved by debate or consulting a third evaluator. These evaluators have extensive experience in assessing the methodological quality of articles, particularly in sports science. The instrument used was the STROBE checklist, which includes 22 criteria for measuring the methodological quality of studies (57). The procedure for using STROBE was according to the following parameter: for each item, scores were given from 0 (the answer was "no") or 1 (the answer was "yes"). At the end of the classification, a score was generated for each study based on the scores for each item. The quality of the studies was classified as high (final score $\geq$ 70%), moderate (final score $\geq$ 60%), and low (final score $<$ 60%). Cohen's kappa (16) coefficient of interrater agreement, shows substantial agreement (k = 0.628).

RESULTS

Through our systematic search, 169 studies were extracted, 37 of which refer to the PubMed database, 62 from the Scopus database, 48 to the Web of Science, and 22 to the SportDiscus. Considering the inclusion and exclusion criteria for this study and the complete reading of the articles, a sample of 23 articles constituted the full analysis. Figure 1 represents the flow chart of this systematic review.

QUALITY OF STUDIES

All studies showed moderate to high methodological quality, which indicates the quantity of information provided by the authors of the primary studies. No study was excluded because of low-quality scores. However, although the studies had different methodological goals, the analysis focused mainly on the isokinetic assessment protocol.

PROTOCOL PROPOSAL

All studies instructed subjects to refrain from moderate- or high-intensity exercise for 48 h before testing to avoid interference of variables that could compromise the test results. Some authors stated that the assessments should take place on 2 separate days, with an interval of 48–96 hours, and an analysis should be made of whether there are significant differences between both moments, to obtain reliable results from individuals with IDD. However, this situation was not observed in all studies.

The assessment protocol should include several phases, which are described below.

Warm-up. An evident aspect of most studies is the warm-up before implementing the isokinetic strength assessment protocol. This warm-up lasted from 3 to 10 minutes, in which a cycle ergometer was used (4), namely a static bike (5,44,52,53,56), a Schwinn Air-Dyne (18,42), a treadmill (18), or through a simple walk at a comfortable intensity (12–14). At the same time, some studies performed stretching as a way of warm-up (30,41). Rosety et al. (46) and Zafeiridi et al. (58) combined the 2 methodologies, that is, prescribed a warm-up through a cycle ergometer and performed it after stretching. Although considered an important phase, other studies did not mention if a warm-up was performed before the isokinetic strength assessment (15,17,21,23,31,40,55).

Adjustment of the equipment and participant according to the manual or/and protocol. A correct calibration using the manufacturer's equipment specifications before the evaluations is essential (12–14,44), as is a correct vertical and horizontal adjustment of the dynamometer according to the participant (4,5,12–14,17,18,21,30,41,44,46,52,53,56,58). Although manuals may differ from model to model, it is important to describe the main procedures to be taken into account: (a) seated in the chair with a solid back support (85° hip flexion); (b) stabilization straps (velcro straps) at the trunk, thigh, pelvis, and tibia to prevent extraneous joint movement; (c) tested knee positioned at 90° flexion (0° = fully extended knee); (d) parallel alignment of the limb to be evaluated with the lever arm of the dynamometer; (e) alignment of the anatomical axis of rotation of the joint with the rotational axis of the dynamometer, considering the distal point of the lateral condyle of the femur (the fixing strip of the pad was adjusted 2 cm above the upper edge of the fibular malleolus); (f) lever pad placed on the distal anterior tibia 3–5 cm above the lateral malleolus; and (g) arms comfortably across the chest.

Knee extensors and/or flexors and both limbs or only the dominant limb. Suomi (53) did not evaluate the 2 movements, extension and

Table 2
Characteristics and protocol of the studies included in review

Author, and year	Aims	Participants	Assessment instruments/ angular velocity/other observations	
Angelopoulou et al. (4)	Assess differences in isokinetic muscle torque in the knee among IDD individuals with DS, IDD individuals without DS, and sedentary subjects without IDD	$N = 27$; 24.9 ± 4.9 y; mild-to moderate IDD (DS inclusive)	Knee extension and flexion of the right lower extremity—Cybex II isokinetic dynamometer (Lumex Inc., Ronkonkoma, NY 11779)—60, 120, and 300°/s	High methodological quality
			Testing was performed on 2 separate days	
			Warm-up on a cycle ergometer (6 min)	
			Adjustment of the equipment and participant according to the manual or/and protocol	
			Test was performed only once, with 5 min of preliminary testing—3 test repetitions—30-s rest period between each trial and 60 s each velocity measurement	
			Instruction to maximally exert each contraction, during every trial (verbal encouragement)	
Angelopoulou et al. (5)	Compare the bone mineral density of men with DS to otherwise IDD men and to investigate leg muscle strength	$N = 16$; 23.7 ± 3.9 y; mild-to-moderate IDD (DS inclusive)	Right quadriceps femoris and hamstrings muscles—Cybex II isokinetic dynamometer (Lumex Inc, Ronkonkoma NY)—PT at angular velocities at 60, 120, and 300°/s	High methodological quality
			6-min warm up—bicycle ergometer	
			Adjustment of the equipment and participant according to the manual or/and protocol	
			Three test repetitions—30-s rest period between each trial and 60 s each velocity measurement	
			Instruction to maximally exert each contraction, during every trial (verbal encouragement)	

(continued)

Table 2 (continued)

Carmeli et al. (12)	Compared isokinetic leg strength of aged individuals with IDD with and without DS	$N = 25$; 61.92 ± 2 y; mild IDD (DS inclusive)	Biodex dynamometer, Medical Systems, Shirley, NY—knee extension and flexion strength was measured bilaterally Warm-up consisting of a 3-min velocity walk Adjustment of the equipment and participant according to the manual or/and protocol 10-min practice session (5 repetitions of knee extension and flexion) at a velocity of 60°/s After this practice, the subjects then performed 3 maximal voluntary contractions at a velocity of 60°/s	High methodological quality
Carmeli et al. (13)	Compare lower limb isokinetic muscle power, locomotor performance and flexibility of aged adult IDD individuals with and without DS	$N = 20$; 57–65 y; mild IDD (DS inclusive)	Knee extension and flexion power—isokinetic system (Biodex dynamometer, Medical Systems, Shirley, NY)—dynamic torque, dynamic torque percent body weight and average power 3 min warm-up walking at a comfortable velocity Adjustment of the equipment and participant according to the manual or/and protocol Five practice repetitions for knee extension and flexion at a velocity of 90°/s Three maximal voluntary contractions at a velocity of 90°/s	High methodological quality
Carmeli et al. (14)	Effects of physical exercise on isokinetic leg strength and dynamic balance	$N = 26$; 57–65 y; mild IDD (DS inclusive)	Knee extension and flexion strength—isokinetic system (Biodex dynamometer; Medical Systems, Shirley, NY)—PT, PT percent body weight, and average power	High methodological quality

Table 2 (continued)

			3-min warm-up walking at a comfortable velocity Adjustment of the equipment and participant according to the manual or/and protocol Familiarization with the equipment Five practice repetitions for knee extension and flexion at a velocity of 60°/s and 120°/s Three maximal voluntary contractions at a velocity of 60°/s and 120°/s	
Carmeli et al. (15)	Investigate the effect of physical training on balance, strength, and general well-being in adult people with IDD	N = 22; 54–66 y; mild IDD	Knee flexion and extension strength, 60°/s (Biodex, Medical Systems, Shirley, NY) Warm-up Three maximal repetitions of knee flexion extension at velocities of 60°/s	Moderate methodological quality
Cowley et al. (17)	Examine the effect of progressive resistance training on leg strength, aerobic capacity and physical function in persons with DS	N = 30; 28 ± 8 y; DS and mild IDD	Knee extensor and flexor PT—Biodex System 3 dynamometer (Biodex Medical Systems, Shirley, NY) Adjustment of the equipment and participant according to the manual or/and protocol Three sets of 5 maximal contractions with the knee extensors and flexors at 60°/s with 3 min between set	High methodological quality
Croce et al. (18)	Compare isokinetic hamstring and quadriceps peak torque (Nm), average power (watts), and corresponding hamstring/quadriceps ratios of adult with DS	N = 22; 25.9 ± 4.3 y; IDD (DS inclusive)	Dominant side—the dominant leg was defined as the leg the subject used or would use to kick a ball PT and average—60°/s and 90°/s (Cybex 340 isokinetic dynamometer) Testing was performed on 2 different days, with 48–96 h between test days	High methodological quality

(continued)

Table 2 (continued)

			Warm-up (6–10 min on either a Schwinn Air-Dyne ergometer or a treadmill)	
			Adjustment of the equipment and participant according to the manual or/and protocol	
			Ten practice repetitions, beginning at a low effort and gradually increasing to efforts of high intensity, for leg extension and flexion at a velocity of 60°/s	
			Two sets of 3 maximal efforts at 60°/s	
			After a 1-min rest, subjects performed 2 sets of 3 maximal efforts at 90°/s	
Eid et al. (21)	Investigate the effects of isokinetic training on muscle strength and postural balance in children with DS	$N = 31$; 9 to 12 y; DS	PT of the knee flexors and extensors of both sides 120°/s Biodex System 3 dynamometer (Biodex Medical System, Shirley, New York)	High methodological quality
			Adjustment of the equipment and participant according to the manual or/and protocol	
			10 concentric contractions at 120°/s (flexion and extension) and the measurement test were repeated 3 times	
Frey et al. (21)	Compare physical fitness levels of trained runners with mild IDD	$N = 9$; 28.7 $\pm$ 7.4 y; mild IDD	Dominant knee extensors and flexors—isokinetic dynamometry (KINCOM 500-H, Chattecx)	Moderate methodological quality
			Familiarization and practice	
			Five trials were conducted at 60°/s	
Horvat et al. (30)	Compare isokinetic knee strength of nondisabled youth and youths with IDD	$N = 30$; 10 to 16 y; mild to moderate IDD	PT, time to PT, angle of PT, total work, and PT hamstrings/quadriceps ratio—of 60°/s	High methodological quality
			Stretching exercises (10 min) and practice extension/flexion with the dynamometer	

Table 2 (continued)

			Adjustment of the equipment and participant according to the manual or/and protocol	
			3–5 submaximal repetitions—test	
			The subject performed a max-effort knee extension followed by a max-effort knee flexion throughout the range of motion; this procedure was repeated for 6 continuous extension-flexion repetitions; no rest was allowed between the extension-flexion repetitions—Kin-Com isokinetic dynamometer	
			Adjustment of the equipment according to the manual	
Ko et al. (31)	Investigate the effects of physical activity on the muscular strength of the lower extremities of IDD adults	$N = 10$; 47.5 ± 2.75 y; IDD	Isokinetic device (Cybex 770)—flexors and the extensors of the knee joint	High methodological quality
			Rehearsed the procedure 3 times in advance before the actual measurement	
			Muscular strength was measured 5 times at a loading rate of 60°/s, which was focused on the knee joint	
Pitetti et al. (42)	Compared isokinetic arm and leg strength of individuals with DS, with IDD without DS and sedentary young adults with no IDD	$N = 36$; 25.6 ± 4 y; IDD (DS inclusive)	Knee extension and flexion (Cybex 340 dynamometer)	High methodological quality
			Dominant side—the dominant leg was defined as the leg the subject used or would use to kick a soccer ball	
			PT, PT percent body weight, average power, and average power % body weight	
			Testing was performed on 2 different days, with 48–96 h between test days	
			Warm-up submaximal exercise (either a Schwinn Air-Dyneb ergometer) at a workload ranging	

(continued)

Table 2 (continued)

			between 25 and 100 watts (6 min)	
			Ten practice repetitions for leg extension and flexion at a velocity of 60°/s	
			Four repetitions, 2 at moderate velocity and the final 2 at maximal velocity; within 10 seconds after the 4 repetitions, subjects performed 2 sets of 3 maximal efforts, with 30 s between sets	
Pitetti & Boneh (40)	Compare cardiovascular fitness to leg strength of young adults with MR with and without DS and to determine whether a relationship exists	$N = 30$; 27.2 ± 4 y; DS	Two sets of 3 maximal efforts, with 30 s between sets a velocity of 60°/s	High methodological quality
			PT, average power and expressed relative to body weight—knee extension and knee flexion of the dominant leg	
			The dominant arm was defined as the limb the subject used or would use to throw a ball	
Pitetti & Fernhall (30)	Evaluate the relationship between aerobic capacity and leg strength of youths with IDD	$N = 29$; 14.2 ± 2.1 y; mild-to-moderate IDD	Knee flexion and extension—dominant side (the leg used to kick a soccer ball)—Kin-Com M500 H dynamometer, a velocity of 60°/s (Chattex Corporation, Chattanooga Group, Inc.)	High methodological quality
			PT, peak force, and average force	
			Adjustment of the equipment and participant according to the manual or/and protocol	
			Stretching exercises of the quadriceps and hamstrings before performing the test	
			Practiced the knee extension/flexion movement until the they demonstrated proper testing procedure	
			5 min after the practice session, subjects performed 2 sets of 6 repetitions, with a 3-min rest period between sets	

Table 2 (continued)

			Subjects were verbally encouraged to perform as vigorously as possible	
Raulino et al. (44)	Measure muscle strength (isokinetic) and activities of daily living in individuals with IDD	$N = 40$; 21.6 ± 4.8 y; mild-to-severe IDD	PT—Biodex System 3 Pró (Biodex Medical, Shirley, New York) Warm-up 5 min on a 25-watt calibrated exercise bike and stretching of knees Adjustment of the equipment and participant according to the manual or/and protocol Familiarization—4 submaximal repetitions After 1 min, the individual performed 2 sets with 4 maximum repetitions of knee flexion and extension in concentric-concentric 60°/s	High methodological quality
Rosety-Rodriguez et al. (46)	Effect of strength training on antioxidant defence system in sedentary DS	$N = 36$; 28.1 ± 3.3 y; DS (mild IDD)	PT of flexion and extension of the of the knees—isokinetic dynamometer at 90°/s—Technogym-REV 9000 (Technogym Spa, Gambettola, Italy) Warm-up—stationary bicycle at a comfortable pace and light stretching leg exercises Adjustment of the equipment and participant according to the manual or/and protocol Participants were asked to exert the maximal force over the full range of motion	High methodological quality
Suomi et al. (51)	Determine the reliability of isokinetic and isometric measurement of strength for tests of knee extension and hip abduction on individuals with mental retardation	$N = 22$; mean age: 30.3 y; mild-to-moderate IDD	Isokinetic knee extension on both limbs 5-min warm-up period—pedaling a bicycle ergometer at a submaximal level Initial warm-up of 10 repetitions of knee extension at 60°/s	High methodological quality

(continued)

Table 2 (continued)

			After a l-minute rest, the subjects performed 4 maximal repetitions at 60°/s (knee extension)	
			A 2-min rest was then provided, followed by 3 sets of 4 maximal contractions at 60°/s for knee extension	
			Peak torque—total work	
Suomi et al. (52)	Effects of hydraulic resistance training on total work and PT measures on men with IDD	$N = 22$; 30.1 ± 5.8 y; mild-to-moderate IDD	Musculoskeletal Evaluation, Rehabilitation and Conditioning (MERAC) systems dynamometer (Universal Gym Equipment, Cedar Rapids, IN)	High methodological quality
			Total work and PT—knee extension for each limb	
			All subjects were tested under comparable conditions by the same tester who was a certified athletic trainer	
			One day before the test session, each subject attended an orientation session to ensure their understanding of the test protocol	
			Previous research has indicated that at least 2 test sessions are required to obtain reliable isokinetic test results from subjects with MR	
			5-min warm-up—pedalled a bicycle ergometer	
			Adjustment of the equipment and participant according to the manual or/and protocol	
			Initial warm-up of 10 repetitions of knee extension (KE) at 60°/s	
			After a 1-min rest, 4 maximal repetitions of the knee extension test at 60°/s	
			2-min rest period was followed by the actual test session, which consisted of	

Table 2 (continued)

			3 sets of 4 maximal contractions conducted at a velocity of 60°/s with a 1-min rest period between sets	
			No verbal prompting (feedback) was provided	
Suomi (53)	Compare isokinetic measures of PT and total work in men with IDD	$N = 12$; 27 ± 6.1 y; mild-to-moderate IDD	Isokinetic knee extension test at a velocity of 60°/s—Musculoskeletal Evaluation, Rehabilitation, and Conditioning (MERAC) Systems Dynamometer	High methodological quality
			Total work and PT—knee extension for each limb	
			All subjects were tested under comparable conditions by the same tester who was a certified athletic trainer	
			One day before the test session, each subject attended an orientation session to ensure their understanding of the test protocol	
			Previous research has indicated that at least 2 test sessions are required to obtain reliable isokinetic test results from subjects with MR	
			5-min warm-up period in which they pedalled a bicycle ergometer	
			Adjustment of the equipment and participant according to the manual or/and protocol	
			Warm-up of 10 repetitions of knee extension at 60°/s	
			After a 1-min rest, the subjects performed 4 maximal repetitions of the knee extension test at 60°/s	
			2-min rest period was followed by the actual test session, which consisted of 3 sets of 4 maximal contractions conducted at	

(continued)

Table 2 (continued)

			a velocity of 60°/s with a 1-min rest period between sets	
			No verbal prompting (feedback) was provided	
Tsimaras and Fotiadou (55)	Evaluate the effect of training on the muscle strength and dynamic balance ability of adults with DS	*N* = 25; mean age: 24.5 y; DS	PT of knee extension and flexion—Cybex II isokinetic dynamometer (Lumex Inc., Ronconkoma, NY)	High methodological quality
			The research protocol took place during 2 separate days of testing spaced 48–72 h apart	
			25 repeated maximum efforts at an angular velocity of 180°/s	
Tsimaras et al. (56)	Evaluate the effect of basketball training on the muscle strength of adults	*N* = 16; mean age: 25.9 y; IDD	Knee extensor and flexor muscle groups—maximal isometric and isokinetic concentric and eccentric torque—Cybex Norm isokinetic dynamometer	High methodological quality
			Warm-up—5 min of cycling on a Monark ergometer (Monark Exercise AB, Vansbro, Sweden)—cadence at which they felt comfortable	
			Adjustment of the equipment and participant according to the manual or/and protocol	
			A series of submaximal isometric, concentric, and eccentric contractions at 60°/s	
			3 reciprocal maximal concentric and eccentric contractions and 3 maximal isometric contractions of knee extensors and flexors, with a 3-min interval between them	
Zafeiridis et al. (58)	Examined fatigue profile during intermittent exercise in 10 men	*N* = 10; 24 ± 3.3 y; mild to moderate IDD	4 sets of 30 s (18 maximal flexions and extensions of the knee joint—120°s^{-1}), with a 60 s rest interval between sets (isokinetic dynamometer (Chatanooga Group Inc.)	High methodological quality

Table 2 (continued)

			5-min warm up on a bicycle ergometer at a heart rate of 120–130 bpm, and 5 min of stretching exercises	
			Adjustment of the equipment and participant according to the manual or/and protocol	
			Only the leg of preference was tested	

Bpm = beats per minute; DS = Down syndrome; IDD = intellectual developmental disabilities; N = participants; PT = peak torque.

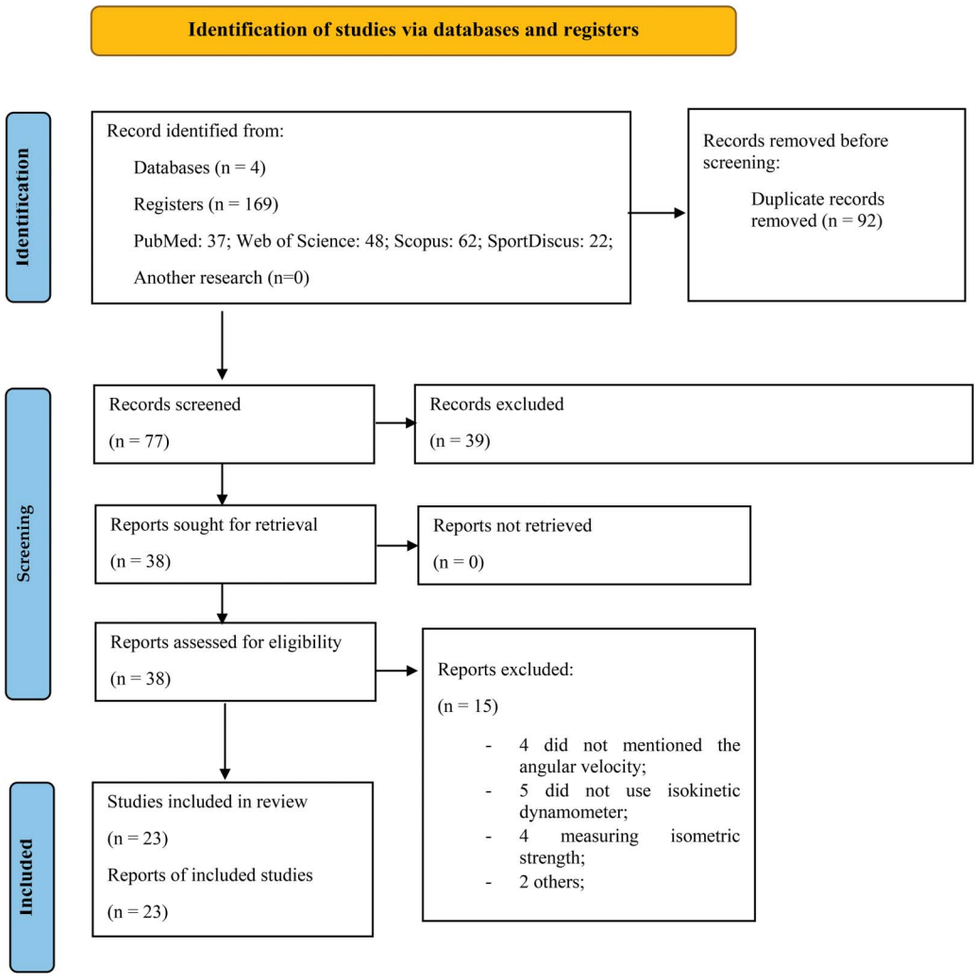

Figure 1. PRISMA flow diagram illustrating each phase of the search and selecting process.

flexion of the knee, having only evaluated the knee extension. The evaluation of the agonist and antagonist muscles (concentric or eccentric actions) allows us to assess the imbalance and/or weakness between them, namely in stabilizing the knee joint (37), because disparate values are considered a sign of injury (47,54).

Some studies assessed only the dominant limb (18,23,40–42,58). Of these studies, some specify how the dominant limb of these individuals was defined (18,40–42). Angelopoulou et al. (4,5) only evaluated the right knee, regardless of whether it was the dominant limb. Many studies have evaluated both knees (47% of the studies extracted) (12–15,17,21,31,44,52,53,56). A small number of studies did not specify which limb was evaluated (30,46,55).

Repetitions/sets/rest. In relation to the number of repetitions or sets and the rest duration, there was a great heterogeneity of protocols. This can be observed in studies that evaluate 1 set (12,30,31,55), 2 sets (18,40–42,44), 3 sets (4,5,17,21,52,53,56), or 4 sets (58) in each angular velocity. The number of sets to assess isokinetic strength varied from 1 to 4, with most prescribing 3 sets.

Regarding repetitions per set, it can be observed that studies that tested 1 (4,5,56), 3 (13–15,18,40,42,56), 4 (52,53), 5 (15,21,23,27), 6 (30,41), 10 (21), 18 (58), and 25 repetitions (55), where high repetition numbers are associated with other aims, such as the analysis of muscle fatigue (58). Most studies tested isokinetic strength using 3 repetitions per set of angular velocity.

Some studies presented 30 seconds of rest between each set (4,5,40,42), whereas others presented 60 seconds (52,53,56,58) or 3 minutes of rest (17,41,56). Some studies combined 60 seconds of rest between each angular velocity (4,5).

Angular velocities. Most studies, namely 73%, only assessed the isokinetic strength of individuals with IDD at a single angular velocity (13,15,17,21,23,30,31,40–42,44,46,52,53,55,56,58). Carmeli et al. (14) and Croce et al. (18) evaluated 2 angular velocities, and the studies of Angelopoulou (4,5) tested 3 angular velocities. The evaluated angular velocities tested were 60, 90, 120, 180, and 300°/s; however, 73% of the studies only tested the angular velocity of 60°/s (4,5,12,14,15,17,18,23,30,31,40–42,44,52,53,56).

Some studies indicate that the test-retest reliability of the isokinetic strength test at fast velocities, namely above 180°/s, in individuals with IDD is not as reliable as tests performed at slower velocities (29,43) because of their neuromuscular system, indicating a need for additional practice and familiarization with the test procedures.

Evaluated variables. Variables considered for analysis were: (a) absolute dynamic torque and in percentage of body weight; (b) absolute peak torque and in percentage of body weight; (c) time to peak torque; (d) angle of peak torque; (e) total work; (f) peak torque ratio hamstrings/quadriceps; (g) absolute average power and in percentage body weight; and (h) peak force and average force. However, peak torque was the most common variable evaluated in all studies. Peak torque is the highest torque value output reached by the joint because of muscle contraction as the knee moves, in flexion or extension, through the range of motion.

DISCUSSION AND PRACTICAL APPLICATIONS

This study discusses articles that have used this methodology in recent years and to present a suggested method to be adopted to assess knee isokinetic strength in this population, which is an assessment of neuromuscular function, functional capacity, and, consequently, perceive quality of life (9,27,34).

Isokinetic strength assessment is a reliable method to measure the muscle performance of individuals with IDD, namely, to assess the work performed for clinical, rehabilitation, or performance purposes (43). In recent years, some researchers have established their protocol and presented some recommendations and practical implications regarding the isokinetic assessment process, which was shown to be different among the studies (9,27). This fact is because of the evolution of science and greater research in this area, which lacks recent studies that provide guidelines that encompass and discuss all the information.

The current systematic review made it possible to discuss the manuscripts that have used this methodology in recent years and to present a protocol to be adopted. Considering the studies extracted from this systematic review, we recommend (a) avoiding moderate or vigorous intensity physical activity in the 48 hours before the assessments; (b) if possible, repeating the assessments on 2 different days, 2 to 4 days apart, keeping the assessment at the same time of the day. However, in the moment of evaluation, we recommend:

- Warm-up–before the isokinetic strength assessment, a 3- to 10-minute warm-up should be performed, using cycle ergometers or a low-intensity walk.
- Familiarization–participants must perform a process of familiarization with the isokinetic equipment before strength assessment. Familiarization or training with the equipment should be considered in future studies because the individual needs to understand the assessment protocol and the intended movement and diminish the learning effect's impact on results. Three-trial repetitions for each angular velocity and action should be performed to familiarize the participant and eliminate the learning curve effect.
- Equipment adjustment–this should be performed according to the manufacturer's manual and standardized protocol. In addition, correct alignment of the equipment is essential to obtain reliable results; assessment of knee flexion and extension–both knees (dominant and non-dominant), to allow imbalance analysis, besides testing concentric action, for both flexion and extension, with the possibility to include eccentric testing, although it

can be difficult to test in this population (IDD) besides increasing the risk of injury. In healthy adults, the average peak torque ratio of flexors and extensors ranges from 50 to 80%, according to different angular velocities (11,45). However, there is a lack of studies with information on individuals with IDD. It is important to evaluate both limbs to assess strength imbalances between dominant and nondominant muscle groups (19). In addition to being essential for motor skills and exercise, games, and sports activities (22,48), muscle performance is crucial for success in activities of daily living (22,44). This physical capacity must be recognized as a prerequisite of global health (22) and evaluated as comprehensively as possible, to better plan physical exercise and analyze its impact, promoting physical fitness and quality of life.

- Number of sets and repetitions–1 to 4 sets, with a preference for 3 sets. In each set, participants perform 3 repetitions.
- Test order–reciprocal test is expected, associating knee extension and flexion, testing the same muscle action. If both muscle actions are tested, it should start by testing the concentric action.
- Rest period–60 seconds between trial repetitions and test, 60 seconds of rest between each set, and 60 seconds between each angular velocity. If concentric and eccentric actions are tested at the same angular velocity, an interval of 60 seconds between trials is suggested.
- Angular velocity–test at an angular velocity of 60°/s, and, if an additional velocity is to be tested, it should be lower than 180°/s. Therefore, it is recommended that the assessments be performed with an angular velocity of no more than 180°/s. Considering that the ability to perform daily life tasks depends mainly on movements at low angular velocity, it is suggested to focus testing on lower angular velocities, such as 60°/s. If more than 1 angular velocity is tested, start with the lower one.
- Evaluated variables–consider peak torque, the best repetition for the muscle action(s) in analysis, and each of the angular velocities tested. Also, consider determining a composite ratio, the conventional (knee flexion concentric peak torque-to-knee extension concentric peak torque). Considering the population and study goals could be of interest to determine other variables such as mean torque or angle at peak torque.

Knowing that the quality of life of individuals with IDD may be associated with the performance of an isokinetic strength test; the conclusions of this study are important because they provide a useful tool with which future researchers, clinicians, or exercise professionals can support their methodological decisions. Also, knowing that physical fitness (namely neuromuscular capacity) is related to the survival of individuals with IDD and that these individuals tend to adopt sedentary lifestyles and physical inactivity, physical exercise should be seen as an integral part of the daily life of this population (7,38). Recent publications have drawn attention to the high frequency of physical inactivity (32). These articles highlight the harmful effects of physical inactivity and sedentary behavior on the individual's environment and health (32). The necessity of investigating, which focuses on increasing physical activity levels in specific population groups, has been emphasized as an important step toward resolving this problem (8). However, isokinetic assessment allows a complete knowledge of the neuromuscular capacity, which is essential for planning exercise programs for recreational and social purposes and for the development of motor skills and fitness in rehabilitation, exercise, and sport (58).

Considering that this is a descriptive study, these proposals should be interpreted with caution, in the sense that future studies should test their reproducibility and reliability. Such procedures are essential for the protocol to be reliable and to ensure that the observed changes in performance over the various assessment times reflect real data and are not merely artifacts of the measurements or procedures, minimizing the amount of measurement error and deviation between the true and observed score (26). However, this work encompasses several age groups, which could potentially be confounding variables.

CONCLUSION

Through the present systematic review, some guidelines are provided for an assessment protocol when evaluating the knee isokinetic strength of individuals with IDD. This protocol includes recommendations for preparation (2 topics) and during the isokinetic assessment (9 topics) of individuals with IDD. It is intended that this document will provide information for developing a useful tool for the various stakeholders interested in assessing the isokinetic knee muscle strength of individuals with IDD.

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