The influence of external and internal focus of attention instructions on the organisation of movement: A systematic review

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Abstract

The relationship between focus of attention instructions and motor performance is a topic of significant research interest. It is widely accepted that attending to the mechanics of the movement when performing a motor task (internal focus) yields poorer performance and less effective movement organisation than attending to the movement outcome (external focus). Specifically, an external focus is suspected to promote more flexibility in the motor system, inducing more effective muscular activity and movement kinematics, which are mechanisms directly responsible for organisation of the resulting movements. However, no review has systematically assessed the influence focus of attention instructions have on muscular activity and movement kinematics. The purpose of this systematic review was to examine evidence on the effect that focus of attention instructions have on the underpinning mechanisms of movement organisation. Adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, a comprehensive electronic literature search yielded 36 research studies. Using a narrative methodological approach, the findings were thematically analysed and synthesised. Generally, external focus of attention instructions resulted in muscular activity and movement kinematic profiles that reflect more effective movement organisation than those resulting from the provision of internal focus instructions; thus, supporting a central tenet of the constrained action hypothesis.

Keywords: focus of attention; movement kinematics; muscular activity; motor learning; instruction

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Instructions are an effective means to help individuals learn movements and improve their motor performance (Hodges & Franks, 2002). Instruction in movement related contexts should aim to convey task-relevant information that facilitates the successful coordination of the motor system to achieve the goal of the movement (Newell & Ranganathan, 2010). Instructions are typically administered verbally by practitioners (Rink, 2013; Yamada et al., 2020) and the phrasing of instructions is critical. Altering just a few words can affect the direction of the performer's/learner's attention and, in turn, impact motor learning and performance (Chua et al., 2021; Yamada et al., 2020). Specifically, instructions that direct attention to the effect of a movement (e.g., the motion of the object being manipulated) rather than the organisation of the movement itself (e.g., the motion of a significant body part) have been shown to result in better performance (Lohse et al., 2010; Lohse et al., 2012; Marchant et al., 2009; McNevin et al., 2003; Wulf & Su, 2007; Wulf et al., 2004) and larger learning gains (An et al., 2013; Zentgraf & Munzert, 2009). Wulf et al. (2001) conceptualised the *constrained action hypothesis* to explain this trend. They argued that drawing a performer's attention to the organisation of the movement "constrains the motor system" (p.1144) whereas attention to the movement outcome or effect "allow[s] the motor system to more naturally self-organize, unconstrained by the interference caused by conscious control attempts - resulting in more effective performance and learning" (p. 1144).

Subsequently, a body of research has emerged to test the two central tenets of the constrained action hypothesis: i) attention to the movement outcome or effect lessens attentional demands; and ii) attention to the organisation of the movement detrimentally interferes with the coordination of a movement. Regarding the former, empirical manipulation and measurement of attention (using dual-task methods, such as probe reaction time) has found evidence of external focus of attention instructions lessening the attentional demands of a motor task (Poolton et al., 2006; Sherwood et al., 2020; Totsika & Wulf, 2003; Wulf et al., 2001). Taking a more neurophysiological approach, Parr et al. (2023) measured participants cortical activity during isometric contractions of the right-hand using electroencephalograms (EEG). Parr et al. (2023) reported that when participants were provided internal focus of attention instructions, parieto-occipital alpha activity and lower frontal midline theta activity was higher than after an external focus of attention instruction was provided. Increased parieto-occipital alpha activity is thought to reflect increased inhibition (Klimesch et al., 2007) while decreased frontal midline theta activity is associated with reduced processing of task-relevant information, disrupting the sensory and motor pathways (Parr et al., 2023). For this task, directing attentional resources to the control of movement appeared to have a disruptive impact on well-formed, automated neuromuscular pathways.

Equally well-considered by the literature, is the notion that directing attention to the mechanics of the movement detrimentally interferes with the organisation of a movement. Specifically, movement organisation refers to how the motor system is coordinated to produce a response to a task (the motor problem). The motor system is challenged by the abundance of ways multiple joint movements can be organised via the recruitment and coordination of multiple motor units across multiple muscles (Bernstein, 1967). Therefore, biomechanical measurement methods that capture the mechanics associated with movement organisation, such as joint range of motion, movement variability and muscular activity provide insight into how internal focus instructions and external focus instructions differently affect the organisation of movement. Inferences can then be made about the desirability of the movement characteristics.

Greater joint range of motion (JROM) likely enables more optimal configuration of joint and intersegmental angles by granting greater freedom of movement and the necessary time to organise movements that more readily achieve desirable movement outcomes (Anderson & Sidaway, 1994; Chow et al., 2008). In throwing (Lohse et al., 2014), jumping (Mazza et al., 2022; Vidal et al., 2018) and striking tasks (Bull et al., 2023), providing an external focus instruction resulted in greater JROM, as well as superior performance outcomes, compared to when an internal focus instruction was provided. The smaller JROM resulting from the provision of internal focus of attention instructions could be taken as evidence of a more constrained motor system caused by attempts to consciously control the movement (Wulf et al., 2001). In contrast, the external focus instruction encouraged a more unconstrained organisation of the motor system (Vidal et al., 2018) allowing a greater range of motion in the joints to emerge. However, in a drop landing task (Waite et al., 2022), in a volleyball set (Arruda et al., 2024) and in an attempt to promote a forefoot strike pattern in running (Chow et al., 2014), the direction of the focus of attention instruction provided had no significant effect on JROM. Indeed, Moore et al. (2019) found providing an internal focus instruction to be more biomechanically beneficial to encourage recreational runners to transition to a flatter foot angle (i.e., greater JROM). Inconsistencies in the pattern of findings may be due to the challenges of interpreting JROM. Joint and intersegmental angle measurements only capture individual elements of the movement or coordination between particular body segments, making it difficult to draw conclusions on the organisational profile of the movement as a whole (Gray, 2020). For example, the aforementioned Moore et al. (2019) study found that although greater knee flexion was observed when participants were provided with an external focus of attention, thereby representing greater JROM, this did not coincide with changes distally at the ankle, compared to an internal focus.

To better account for the complexities of the motor system, there has been a move in the field to apply the concept of functional variability. Functional variability represents the compensatory or corrective quality of the motor system in response to perturbations (e.g., movement ‘error’) (Latash, 2012). Such synergies, which Latash refers to as “good variance,” afford relatively consistent movement outcomes (Loosch & Müller, 1999). To measure functional variability in a unipedal hopping task, Fietzer et al. (2018) employed the uncontrolled manifold analysis, which factored in foot-to-floor angles, and ankle and knee intersegmental angles for leg orientation during take-off and landing. Motor synergies were quantified by dividing variability into performance-irrelevant variability, supporting greater consistency in terms of the movement outcome (good variance), and performance-destabilising variability, which compromises consistency (bad variance). The external focus instruction produced more good variance over bad variance, that is more functional variability, than the internal focus of attention instruction, enabling the participant to better hop in place. Therefore, yielding more functional variability in the motor system compared to an internal focus instruction.

An alternative approach to evaluate organisation of the motor system is a modified vector coding technique. Simply, this technique can be used to examine coordination between body segments and variability in the movement during a motor task (Chang et al., 2008; Vidal et al., 2018). More specifically, this technique quantifies the angle couplings between pairs of body segments, whereby the coordination between segments is categorised as follows: antiphase coordination - segments rotate in opposite directions; in-phase coordination - segments rotate in the same direction; proximal coordination - proximal segment dominates movement; and distal coordination - distal segment dominates the movement. Importantly, the effectiveness of the movement pattern observed is dependent on the task and the goal of the movement. When applied to attentional focus in a standing long-jump task, Vidal et al. (2018) analysed coordination between the ankle and knee. In particular the vector coding analysis, identified that when provided with an internal focus instruction participants were primarily using their knees to perform the jump. In contrast, an external focus provision promoted the use of both the ankles and knees, representative of more in-phase coordination, indicating enhanced synchronisation and configuration of the body to produce the jump. Despite more optimal coordination between segments with an external focus provision, the vector coding analysis revealed that regardless of attentional focus, no differences in coordination variability (variations in movement over time) at the ankle, knee and hip locations in any of the three phases of the jump were observed (downward phase, transition phase and take-off phase).

At a muscular level, electromyography (EMG) is widely employed to capture muscular activation patterns, whereby lower EMG values are often indicative of a more sophisticated organisation of movement (Chua et al., 2021). A body of experimental research has used EMG to compare muscular activity following the provision of external and internal focus instructions in an array of tasks, such as force-generation (Greig & Marchant, 2014; Lohse et al., 2011; Lohse & Sherwood, 2012; Marchant et al., 2009), far-aiming (Hitchcock & Sherwood, 2018; Lohse et al., 2010; Zachry et al., 2005), speed/movement duration (Kal et al., 2013; Kovacs et al., 2018), and balancing (Ducharme & Wu, 2015). Generally, EMG analysis suggests that external focus instructions produce better (or the same) performance outcomes with less muscular activity (Lohse et al., 2010; Marchant & Greig, 2017) compared to when internal focus instructions are provided. It has been argued that the achievement of more successful or equivalent performance outcomes with lower muscle activation reflects a more economical recruitment of muscle fibres (Chua et al., 2021) indicative of a better organised response to the task (Parr et al., 2023).

Nevertheless, research has not always observed what might be considered superior muscular activity following an external focus of attention instruction. For example, Halperin et al. (2016) reported that despite greater voluntary elbow flexion force production following an external focus instruction, surface EMG analysis did not differentiate the muscular activity of the movements following the provision of different instructions. Similarly, Calatayud et al. (2018a) reported that muscular activity did not vary as a function of focus of attention instruction in an explosive bench press exercise. Only when the ascent and decent time of the barbell was controlled (2 seconds) was an increase in muscular activity associated with the use of an instruction to focus on the major muscle groups (either the pectoralis or the triceps) reported.

Recent systematic reviews have examined the influence of focus of attention instruction on movement outcomes (Kim et al., 2017; Park et al., 2015; Wulf, 2013). Generally, benefits of external focus instructions have been found. Most recently, Chua et al. (2021) conducted a meta-analysis of key performance outcome measures, corroborating the effectiveness of an external focus instruction relative to an internal focus instruction. Additionally, a secondary meta-analysis within the study explored movement characteristics, further highlighting the benefits of external focus instructions for neuromuscular activity.

However, previous work has not quantitively or qualitatively discussed kinematic measures, which encompass JROM, movement variability and functional variability, which are critical to understanding the organisation of the motor action. Alongside this, developments in movement analysis methods that can directly capture the organisation of movement characteristics have produced a large volume of studies in recent years concerning muscular activity and joint kinematics. Accordingly, a systematic review amalgamating the focus of attention and organisation of movement phenomenon is pertinent. Specifically, the primary purpose of this systematic review was to understand how internal focus instructions and external focus instructions differently affect the organisation of movement in healthy adults.

Method

The *Preferred Reporting Items for Systematic Reviews and Meta-Analysis* (PRISMA; Page et al., 2021) guidelines were followed and augmented by guidance from the Centre for Reviews and Dissemination (CRD, 2009) and recent systematic reviews in the field (e.g., Chua et al., 2021). This systematic review was not registered with the International Prospective Register of Systematic Reviews.

Selection criteria

The rules/principles of the inclusion and exclusion protocols described by Meline (2006) were applied, whilst further using the PICO framework (Population, Intervention, Comparison and Outcome) to formulate the following selection criteria: (1) use adult population samples that were free from physical injury and/or infirmity; (2) make deliberate use of both internal and external focus of attention instructions; (3) include quantitative data that is a direct marker of movement characteristics (e.g., quantitative data that directly captures movement either through muscular activity or joint kinematics); (4) use representative sport, exercise or physical activity tasks; (5) contain original empirical peer-reviewed research; and (6) full-text of the research report was accessible and published in English. Studies were excluded on the basis of the following: (1) use of child and adolescent populations (below 18-years of age); (2) no deliberate use of both internal and external focus of attention instructions; (3) participants were not free from physical injury and/or infirmity; (4) did not contain any quantitative data that is a direct marker of movement characteristics (e.g., indirect markers such as, movement adjustment analysis); (5) did not contain tasks in sport, exercise or physical activity; (6) research did not contain original empirical peer-reviewed research; (7) research was published in a language other than English.

Search Strategy

This review was conducted in accordance with the PRISMA guidelines although some compromises were made. A comprehensive search strategy was undertaken, primarily conducted by the lead researcher. However, a double-screening approach employing a second researcher would mitigate potential systematic errors and omissions (Waffenschmidt et al., 2019). The initial search was conducted between April – November 2022 (see Supplemental Material 2) by the lead researcher. In addition, following Gunnell et al's (2022) guidelines, we conducted a final search update before publication because the delay between the first screening and the end of the writing exceeded 12 months (Figure 1). Thus, the updated search commenced upon the finalisation of the initial search, up to the present day, taking place between March – April 2024 and performed by the lead researcher. Research papers were identified from an electronic search of three relevant databases (SPORTDiscus, Scopus and PsycINFO). The key words and search strategy for each of the databases were as follows: ("Attentional focus" OR "focus of attention" OR "attentional focussing" OR "internal focus" OR "external focus") AND ("movement efficiency" OR "movement organisation" OR "movement coordination OR "movement" OR "movement variability") AND ("motor performance" OR "motor development" OR "motor learning") NOT ("rehab" OR "stroke" OR "Parkinson's" OR "surgery" OR "patients" OR "child populations").

Following the electronic search, potentially eligible papers were assessed in accordance with the selection criteria. During the screening phase, the lead researcher independently screened the titles and abstracts of identified records for relevance. If an abstract was deemed relevant, then the full manuscript of the paper was retrieved and assessed for eligibility according to the exclusion and inclusion criteria. In the instance that the lead researcher was unclear whether the inclusion criteria were met, the paper was reviewed with the second, third and fourth author until a consensus was reached. All researchers agreed on the inventory of papers before synthesisation commenced.

The reference lists of all the included papers from the search were examined to identify any significant papers that may have been missed or overlooked by the original search. A general internet search (i.e., Google Scholar) employing a snowballing literature search method was used for citation chaining of the included studies to further identify any papers. Lastly, papers included within previous systematic reviews in the field (i.e., Chua et al., 2021) were checked against the inclusion and exclusion criteria for relevance.

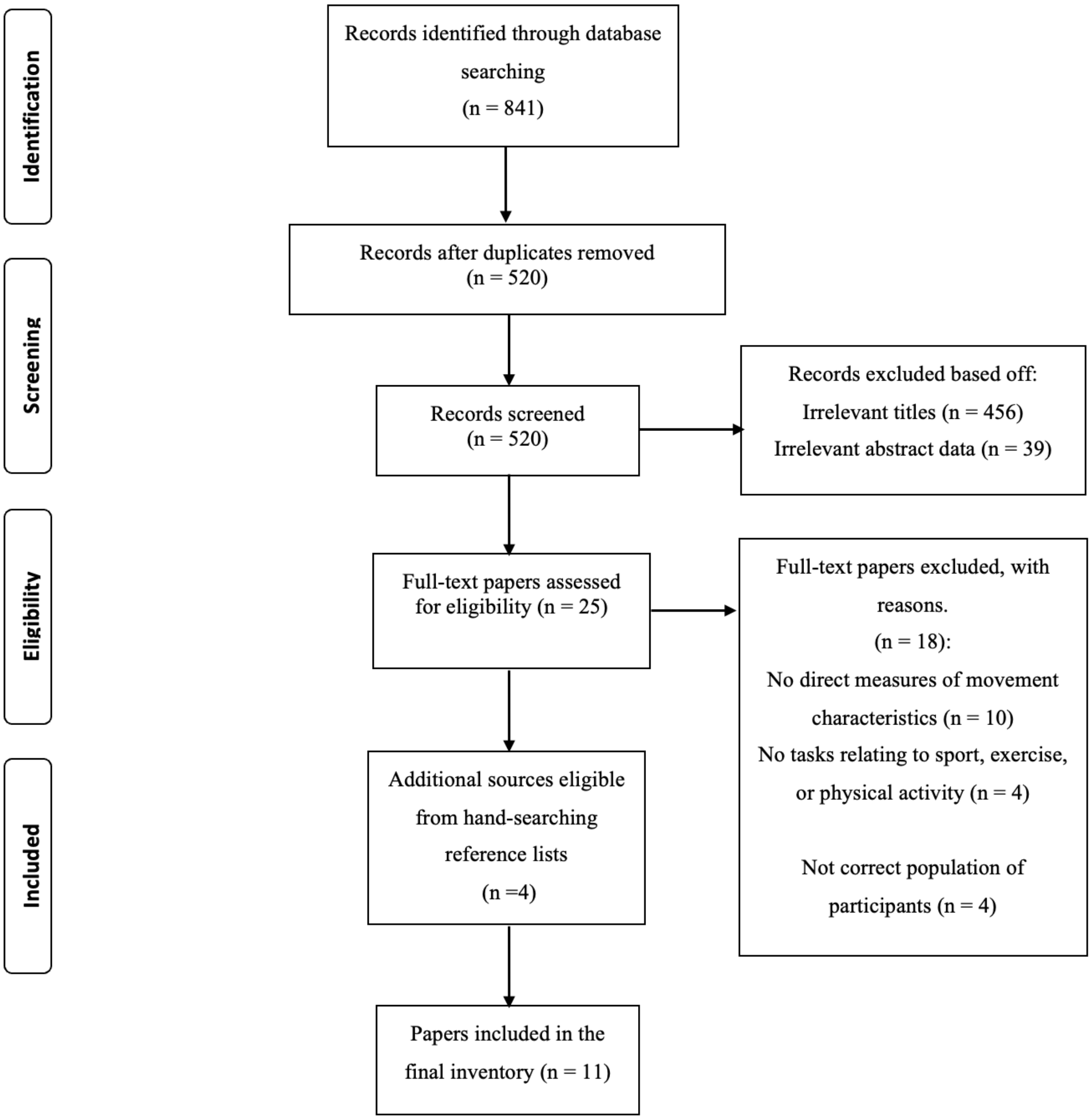
Search Returns

The updated search summarised in Figure 1 returned a total of 841 papers that were potentially eligible. After the removal of duplicates (n = 321) and the screening of titles (n = 456), the abstracts of 64 papers were assessed against the selection criteria. A total of 25 papers qualified for full-text screening. A further 18 papers were primarily excluded on the basis that they did not include any direct markers of movement organisation characteristics; did not include representative tasks in sport, exercise or physical activity; or did not include the correct participant population. Hand-searching resulted in the identification of 4 additional papers that met the selection criteria. In sum, across both searches an inventory of 34 papers containing 36 experimental studies met the criteria for the review (Figure 1 & Supplemental Material 2). Each of the 34 papers were repeatedly read in full by the lead researcher to become familiar with the reported study design and data (Maykut & Moorhouse, 1994). The quality of these sources was examined with reference to the objectives and the inclusion/exclusion criteria.

Figure 1.

Stages and results of the updated search process using the PRISMA guideline framework.

framework. Adapted from Moher et al. (2015).



Data Extraction and Synthesis

The PICO framework was applied to the development of a table for data extraction (see Supplementary Table 1 & 2). Particularly, the tables included study details (author, year of publication, study design); participant's characteristics (mean age, sex, skill level); study characteristics (tasks, focus of attention instructions, order of conditions, manipulation checks, movement analysis and outcome measures); and study results.

Although all papers reported quantitative data, the heterogeneity of the methodological designs and of the outcomes employed across experimental studies meant that a meta-analysis was not suitable. The variations in task complexity and participant characteristics (e.g., age and skill level) make the applicability of the findings difficult and requires translation so the results can be best interpreted. Instead, a narrative synthesisation of the included papers was elected, which enabled the appropriate systematic organisation of central themes (Popay et al., 2007) using a two-stage analysis approach. Initially, findings were organised according to how movement characteristics were measured, given their different kinematic and kinetic quantities (muscular activity and joint kinematics). Following this, lower-order themes that emerged from the review of the papers were identified (e.g., type of task). Considering muscular activity measures (EMG) directly measure when and how much of the muscle is activated, this does not always correspond with effective movement. Thus, throughout the narrative synthesis, kinetic outcomes (e.g., force generation, torques) were reported to better understand the efficiency and effectiveness of muscular activity.

Risk of Bias and Quality Assessment

To address the rigour of studies, full texts were critically appraised by providing an index of quality and to ensure the included studies reached an acceptable scientific standard (Harris et al., 2021). Similar to previous systematic reviews (Harris et al., 2021) a quality assessment scale was adapted from the Quality Index (Downs & Black, 1998), the Checklist for the Evaluation of Research Articles (DuRant, 1994) and the Appraisal Instrument (Genaidy et al., 2007). Whilst a comprehensive risk of bias and quality assessment was performed (see Supplemental Material 3), this was primarily conducted by the lead researcher, and not independently verified, increasing the risk of researcher bias.

Results

General findings

A total of 36 studies taken from 34 journal articles satisfied the inclusion criteria and are summarised in Supplementary Table 1 and 2. A total of 742 healthy participants met the inclusion criteria, including 393 males (52.96%), and 337 females (45.44%), with 12 participants (1.62%) unspecified. Age of participants ranged from 18-55 years with a mean age of 25.66 (SD = 4.57; 8 studies did not specify age). Most studies employed a within-subject (n = 33) rather than a between-subject design (n = 3). Manipulation checks on the adherence to focus of attention instructions were included by 12 studies using rating scales (n = 6), questionnaires (n = 4), interviews (n = 1) and recall compliance forms (n = 1). The most frequently used tasks were force generation (n = 16), accuracy (throwing, hitting and jumping; n = 9) and jumping tasks (n = 4), while the least frequently used tasks were running (n = 3), range of movement (n = 1), landing (n = 1), balance (n = 1) and reaching tasks (n = 1). For 533 participants (71.87%) the task was novel, whereas 209 participants (28.13%) were regarded as skilled/trained. Outcome measures of 26 studies included, accuracy (n = 10), force production (n = 8), speed/movement time (n = 3), jump height (n = 2), distance (n = 2) and displacement (n = 1). Regarding the measurement of the organisation of movement characteristics, 23 studies used surface EMG to analyse muscular activation; and 14 studies employed kinematic analysis methods, which included measures of movement variability, joint angles and intersegmental joint angles.

Risk of Bias and Quality Assessment

The risk of bias and study quality assessment indicated that the studies included in the review displayed a moderate to high degree of rigour. The scores ranged from 78% to 100% with a mean of 90.21% (*SD* = 8.49). The most poorly addressed items were priori determination of sample sizes, characteristics of participants (e.g., age), representativeness of the participant population from which they were recruited and whether the study results can be applied to other relevant populations (see Supplemental Material 4.)

Focus of Attention Effects on Muscular Activation

Of the 23 studies that measured muscular activation using surface EMG, 16 studies examined activity during the completion of tasks with force generation outcomes (Calatayud et al., 2018a; Calatayud et al., 2018b; Coratella et al., 2022; Greig & Marchant, 2014; Halperin et al., 2016; Kristiansen et al., 2018; Lohse et al., 2011; Lohse & Sherwood, 2012; Marchant et al., 2009; Marchant & Greig, 2017; Neumann & Brown, 2013; Parr et al., 2023; Vance et al., 2004; Wulf et al., 2010), four studies examined activity during the performance of far-aiming tasks (Hitchcock & Sherwood, 2018; Lohse et al., 2010; Pellock & Passmore, 2017; Zachry et al., 2005), two studies examined activity during the completion of tasks with speed/movement duration outcomes (Kal et al., 2013; Kovacs et al., 2018) and one study measured activity during the completion of a balance task (Ducharme & Wu, 2015).

Tasks with Force Generation Outcomes

Marchant et al. (2009) found lower peak joint torque over the duration of an isometric elbow flexion movement when provided with an internal focus instruction[1]. This lower force production was accompanied by higher surface EMG activity in the biceps brachii. Using an identical experimental design, Greig and Marchant (2014) reported lower force production was generated when provided with an internal focus instruction, but this was only significant when performing at the slowest speed. Nevertheless, an overall significant main effect of higher surface EMG activity in the biceps brachii were observed when aiming to follow an internal focus instruction. In similar study, Lohse et al. (2011) required participants to produce 30% of maximum force with their dominant leg in an isometric plantar flexion task. Less accurate force production was observed when provided with an internal focus, concomitant with higher surface EMG in the tibialis anterior. Parr et al. (2023) asked participants to maintain a target hand grip force for a duration of 5 seconds. Force precision was poorer when aiming to follow an internal focus provision, and relatively increased the surface EMG activity of the forearm flexor. Marchant and Greig (2017) found type of instruction to have no effect on peak torque during a lower extremity knee extension exercise, however, surface EMG activity of the vastus medialis oblique, vastus lateralis and the rectus femoris was higher when provided with an internal focus instruction.

A two-study paper by Lohse and Sherwood (2012) required participants to perform an isometric plantarflexion task at 30, 60 and 100% of maximal voluntary contraction. Initially, participants were able to generate the target forces under an internal focus

[1] *Note.* Throughout the review of the findings from these studies, the effects of internal focus instructions are reported in direct comparison to the effects of external focus instructions, unless otherwise stated.

instruction provision, but this coincided with higher surface EMG activity of the tibialis anterior and the lateral aspect of the soleus. In the second study, Lohse and Sherwood (2012) considered muscular fatigue by asking participants to maintain the target force until failure. The focus of attention instruction provided had no effect on the time until failure or the accuracy of force generated, however, consistent with the first study, EMG activity of the tibialis anterior and the lateral aspect of the soleus was relatively higher following an internal focus instruction.

A two-study paper by Vance et al. (2004) examined the movement efficiency of a bicep curl by resistance trained participants. In the first study, when provided with an internal focus instruction this was accompanied with lower angular velocity of elbow flexion, but generally no differences in surface EMG activity of biceps or triceps brachii. In the second study, Vance et al. (2004) controlled angular velocity by asking participants to perform the curl in synchrony to a metronome. On this occasion, when provided with an internal focus instruction, this was associated with increased EMG activity in the bicep brachii during flexion of the elbow. An extension of this work by Halperin et al. (2016) recruited resistance trained athletes to perform a maximal voluntary elbow flexion task under internal, external, neutral and a mirror focus condition. Normalized force production was found to be greater when provided with an external focus instruction than all other conditions, however, EMG analysis of both the biceps and triceps brachii found no between condition differences.

Kristiansen et al. (2018) asked resistance trained participants to bench-press 60% of their three-repetition maximum and repeat following a number of conditions. EMG activity of twelve muscle sites (see Supplementary Table 1) found no differences between the two focus of attention instructions, however, mean and peak EMG amplitudes across the six upper body muscles were lower when no instruction was provided. No differences were found between conditions for the six lower body muscles measured. Similar to this, Calatayud et al. (2018a) asked resistance trained participants to bench press 50% of their one-repetition maximum at both a controlled speed and a maximum speed, when attempting to follow two internal conditions and an external condition in a randomised order. Whilst EMG activity of the pectoralis and triceps was lower when provided with an external focus relative to both internal focus instructions in the controlled phase, there remained no significant differences between any of the focus conditions in the maximum explosive speed phase. In an identical study Calatayud et al. (2018b) used different width grips during a bench press but found no interaction with the type of attentional focus (internal or external) on EMG activity of the pectoralis and triceps.

In a related task, Coratella et al. (2022) asked resistance trained participants to back squat 50% and 80% of their one-repetition maximum. During the concentric phase, surface EMG of the gluteus maximus and bicep femoris was greater when provided with an internal focus, but excitation of the vastus lateralis was reduced, while during the eccentric phase surface EMG of the gastrocnemius medialis and tibialis anterior was greater with the internal focus instruction provided.

Neumann and Brown (2013) employed a strength training task of an abdominal curl. In particular focus of attention instructions provided (both internal and external) did not significantly affect the movement time of an abdominal curl but found the range of movement to be lower and EMG activity of the abdominals to be higher when provided with an internal focus instruction.

Wulf et al. (2010) found that vertical jump height was lower when provided with an internal focus instruction. Despite EMG measures finding no differences in muscle onset times, muscular activity of the vastus lateralis was higher when provided with an internal focus instruction.

Far-aiming tasks

Zachry et al. (2005) found that when participants were provided with an internal focus instruction this produced poorer basketball free-throw performance. These performance outcomes were accompanied by higher EMG activity of the biceps and triceps brachii, but no differences in the activity of the flexor carpi radialis or deltoid of the shooting arm. Similarly, Lohse et al. (2010) found throwing accuracy was worse when provided with an internal focus instruction, and that movement onset time and activity of the triceps brachii was relatively increased. Using a similar experimental design, Hitchcock and Sherwood (2018) reported inferior throwing accuracy and higher surface EMG activity of the biceps and triceps brachii with an internal focus instruction provision.

Pelleck and Passmore (2017) provided both novice and skilled golfers external, internal-proximal and internal-distal focus of attention instructions ahead of a block of golf putts. Novice participants were less accurate when instructed to focus on their stance (internal-distal focus) compared to their grip and elbow position (internal-proximal focus), although accuracy was best when instructed to focus on the target (external focus). The putting accuracy of skilled performers was similar regardless of instruction. Furthermore, novice participants experienced higher EMG activity in the arm (extensor carpi radialis) when instructed to focus on their grip and elbow position compared to the stance and the target instruction. No differences in EMG activity in the arm were detected in skilled performers. Regardless of skill level, EMG activity in the lower leg (tibialis anterior) evidenced lower variability when participants were instructed to focus on their stance rather than the target or their grip and elbow condition. These latter findings are at odds with the constrained action hypothesis.

Reaction Time Tasks

Kovacs et al. (2018) asked track athletes to perform a sprint start under several instruction conditions. Rear foot reaction time was slower when provided with an internal focus instruction compared to an external focus instruction. Front foot reaction time was also faster when provided with an external focus instruction than an internal focus instruction but was not different from the no instruction control. Moreover, EMG measurement of the vastus lateralis and the gastrocnemius (left and right) showed relatively slower pre-motor reaction time when provided with an internal focus instruction compared to an external focus instruction.

Tasks with Movement Duration Outcomes

Kal et al. (2013) asked participants to perform a seated cyclic leg extension providing a number of instruction conditions. Despite significantly longer movement cycle times when provided with an internal focus instruction no differences between the two types of instruction were observed in the surface EMG of the vastus lateralis, rectus femoris and the medial semitendinosus, suggesting muscular activity did not vary when provided with either an internal or external focus instruction.

Balance Tasks

Ducharme and Wu (2015) asked participants to perform a dynamic balance task on an uneven surface with view of their lower body and the surface obscured. Lateral displacement was higher (worse performance) when aiming to follow an internal focus instruction and in the control condition, compared to the external focus instruction; however, the instructions did not result in differences in surface EMG of the peroneus longus, tibialis anterior, gastrocnemius lateralis, vastus medialis, and biceps femoris.

Focus of Attention Effects on Movement Kinematics

Of the 14 studies that conducted a kinematic analysis, eleven studies analysed joint angles/intersegmental angles (Bull et al., 2023; Chow et al., 2014; Arruda et al., 2024; Harry et al., 2019; Lohse et al., 2010; Lohse et al., 2014; Mazza et al., 2022; Moore et al., 2019; Schutts et al., 2017; Vidal et al., 2018; Waite et al., 2022) and seven studies included a measure of movement variability (Arruda et al., 2024; Fietzer et al., 2018; Howard et al., 2023; Lohse et al., 2014; Singh et al., 2022; Vidal et al., 2018; Waite et al., 2022).

Joint and Intersegmental Angles

Assessing performance of a vertical jump and reach task Harry et al. (2019) found peak vertical ground reaction forces did not differ because of focus of attention instructions, and hip and knee contributions were also not different. However, the internal focus instruction provided did result in smaller plantarflexion angles at the ankles and knee flexion at ground contact. For a drop landing task, Waite et al. (2022) reported that angle pairings of the hip-knee, hip-ankle and knee-ankle did not differ when aiming to follow the provision of internal, external and control focus of attention instructions.

Vidal et al. (2018) found when provided with an internal focus instruction this resulted in shorter jump distances and more accurate ankle-knee flexion angles during the downward phase of a standing long jump. In the same task, Mazza et al. (2022) found no differences in jump distances, ground reaction forces or peak hip, knee and ankle joint angles when provided with internal, external and control focus of attention instructions, however, the tibial projection angle was significantly higher with an internal focus provision. In addition, a negative increase in barbell cervical hip angle during the maximum height phase of a snatch lift was reported by Schutts et al. (2017) when provided with an internal focus instruction.

In two dart-throwing studies, Lohse and his colleagues captured the joint angle of the throwing arm at the moment of release. Lohse et al. (2010) found no effect of instruction on the joint angles of the shoulder and elbow, whereas Lohse et al. (2014) found lower shoulder, elbow and wrist extension when provided with an internal focus instruction.

Bull et al. (2023) asked skilled cricket batters to perform straight drives when provided with instructions to focus on the movement of their hands (internal) or their bat (external-proximal) or the ball flight of the shot (external-distal). Internal focus instructions good ball contacts were fewer, bad ball contacts were greater and step-length decreased. Additionally, step-length was shorter after the instruction to focus on the movement of the bat compared to the instruction to focus on the ball flight of the shot. However, the different instructions did not result in significant differences in knee flexion angle. In a volleyball setting task, Arruda et al. (2024) found that the setting accuracy of skilled players was poorer when provided with internal and external focus instructions than when no focus of attention instructions were provided (control condition). However, no inter-joint coordination differences were produced by providing either the internal or external focus of attention instruction.

Chow et al. (2014) aimed to get participants to change their running technique from a heel-foot to a forefoot strike pattern. No significant differences in gait characteristics of stride length and cycle time were observed between the type of instruction. Both conditions equally increased plantarflexion and positioning of the ankle, along with calcaneus displacement, representing a forefoot strike pattern. Similar, Moore et al. (2019) attempted to get recreational runners to transition to a flatter foot angle by instructing participants to “run with a flat foot” (p. 1574, internal), to “run quietly” (p. 1574, external) or to be aware of their session objective “we are aiming to change foot strike, so run quietly” (p. 1574, clinical). After the internal focus instruction, greater joint angles at the ankle (flatter foot strike) and smaller joint angles at the knee were observed. Although better knee angles (more flexion) were observed when provided with an external focus this did not coincide with changes distally at the ankle, compared to the internal and clinical focus instructions.

Movement Variability

Lohse et al. (2014) recruited participants to perform a dart-throw under five focus of attention conditions (internal, proximal, external, distal and a free focus), in which accuracy was greater when aiming to follow an external focus relative to all other conditions, generally attempts to follow an internal focus led to poorer performance than all other conditions. In addition, analysis of the shoulder, elbow and wrist in the throwing arm found that when provided with an internal focus this enabled lower trial-by-trial variability. Furthermore, movement compensations of the shoulder, elbow and wrist were significantly lower when provided with an internal focus.

Vidal et al. (2018) found that standing long-jump distance was shorter when provided with an internal focus instruction, but coordination variability at the ankle, knee and hip locations were not significantly different in any of the three phases of the jump (downward phase, transition phase and take-off phase). However, coordination analysis between the ankle and knee identified that when provided with an internal focus, participants were primarily using their knees, whilst the provision of an external focus instruction promoted the use of both the ankles and the knees, indicative of a better coordinated jumping action. Waite et al. (2022) recorded variability between the hip-knee, hip-ankle and knee-ankle angles in a drop jump. Variability was smaller at the hip-knee angle when provided with an internal focus instruction, indicative of a poorer landing technique.

Fietzer et al. (2018) examined movement variability of a unipedal hop when providing participants with different instruction conditions. Hopping in place was poorer when aiming to follow an internal focus. Movement variability measures were calculated from foot-to-floor, and ankle and knee intersegmental angles for leg orientation during take-off and landing. The uncontrolled manifold analysis found that when provided with an internal focus instruction this produced greater destabilising variability, which represents performance inconsistency due to noise in the motor system. In contrast, an external focus instruction provision was found to result in superior stabilising variability, therefore, yielding more functional variability in the motor system.

Singh et al. (2022) captured movement variability using the uncontrolled manifold analysis. In particular, serve accuracy and movement kinematics (shoulder, elbow and wrist) of experienced volleyball players were assessed when provided with external-distal, external-proximal and internal focus instructions. Aiming to follow the external-distal condition produced significantly higher serving accuracy scores compared to the internal and external-proximal condition. In addition, the uncontrolled manifold analysis of the kinematic measures found that when provided with the external-distal condition this produced superior stabilising variability relative to destabilising variability, when compared to the internal and external-proximal condition. Arruda et al. (2024) reported that variability of inter-joint coordination between the elbows and knees during a volleyball set was reduced for both skilled and novice performers when provided with a set of internal and external focus instructions.

Further the uncontrolled manifold analysis was applied by Howard et al. (2023) when participants performed a visually obscured planar reaching task with their dominant and non-dominant arm when provided with internal, external and no focus instructions. Particularly, endpoint accuracy scores when aiming to follow an internal focus produced less accurate and more variable reaching movements. In addition, movement measures of the arm (see Supplemental Table 1) found that when provided with an internal focus this led to higher goal-relevant variance among the joint (destabilising variability) compared to an external focus from the initial 20% of the reach to the end. However, no differences were observed in goal-irrelevant variance (stabilising variability), that is, index of joint variance that does not affect the endpoint position.

Discussion

The purpose of this systematic review was to understand how internal and external focus of attention instructions differently affect the organisation of the movement of healthy adults. In sum, 29 of the 36 experimental studies found that the delivery of an internal focus instruction resulted in movement characterisations that reflect poorer organisation of the motor system compared to an external focus instruction. This was evidenced by generally superior muscular activity and movement kinematic profiles in 18 (50%) and 11 (31%) of the studies included in this review, respectively. In addition, 21 of the 26 studies that employed outcome measures reported inferior performance accuracy ($n = 9$), force generation ($n = 6$), jump height ($n = 2$), speed/movement duration ($n = 2$) distance ($n = 1$) and displacement ($n = 1$) when participants were provided with an internal focus instruction rather than an external focus of attention instruction.

The majority of the findings in this review suggest that when provided with an external focus this supported more desirable movement characteristics. Nevertheless, there were occasions when desirable movement characteristics did not emerge from the provision of external focus of attention instructions. In particular, some studies evidenced no differences in the measures taken when provided with the different types of instructions (Calatayud et al., 2018a; Calatayud 2018b; Chow et al., 2014; Halperin et al., 2016). In two studies, both internal and external focus instructions appeared to compromise movement organisation relative to a control condition when experienced participants performed a bench press exercise (Kristiansen et al., 2018) and skilled volleyball players performed a setting task (Arruda et al., 2024). Considering this, the organisational benefits of an external focus of attention may not generalise to the movement of skilled performers, as they likely adopt a focus of attention strategy that compliments their level of experience and/or skill (Couvillion

& Fairbrother, 2018). These strategies may be deeply ingrained, making adherence to new instructions challenging and ineffective.

Most studies that measured muscular activation found that better or equivalent task performance outcomes (i.e., force production) were associated with less activation of key muscles when participants were provided with external focus instructions. The greater muscular activation provoked by the provision of internal focus instructions is indicative of a constrained recruitment strategy (Lohse et al., 2010; Marchant & Greig, 2017) that overly emphasises certain muscles and impedes the development of effective muscle synergies (Parr et al., 2023). Hyperactivity of key muscles is likely to produce muscle tension (tightness) that limits the joint range of motion and the adaptability of movement in response to perturbations.

There was also evidence of internal focus instructions causing superfluous muscular activation across the muscular skeletal system, not just in the prime mover. Marchant and Greig (2017) found that instructing participants to focus on contracting the vastus medialis oblique muscle during an isokinetic knee extension task increased muscular activation of the vastus lateralis, vastus medialis oblique and rectus femoris; that is, sites that was not specific to the muscles isolated in the task but represented a spreading of increased muscular activity. Such findings suggest that attempting to follow an internal focus instruction can not only have a localised constraining effect but may affect the motor system more widely.

The notion of external focus of attention instructions affording better movement organisation were broadly supported at a kinematic level. Specifically, when provided with an external focus this enabled greater JROM (Harry et al., 2019; Lohse et al., 2014; Mazza et al., 2022; Schutts et al., 2017), contributing to more optimal configuration of joint and intersegmental angles, and also, functional variability (Fietzer et al., 2018; Howard et al., 2023; Lohse et al., 2014; Singh et al., 2022; Waite et al., 2022) enabling corrections/compensations in the movement, to ensure a consistent performance outcome. In contrast, internal focus of attention instructions resulted in lower range of motion at key joints than when participants were provided external focus of attention instructions (Harry et al., 2019; Lohse et al., 2014; Mazza et al., 2022; Schutts et al., 2017). It can be argued that a lower range of motion reflects a constrained motor system because less mobility in the joints of the movement may impact the configuration of more optimal angles and intersegmental angles which facilitates the successful coordination of the motor system.

An extension of these findings was offered through movement variability measures, whereby an internal focus provision often evidenced lower levels of functional variability than when participants were instructed with an external focus instruction (Fietzer et al., 2018; Howard et al., 2023; Lohse et al., 2014; Singh et al., 2022; Waite et al., 2022). Consequently, lower movement variability coupled with less consistency in the performance outcome (i.e., lower functional variability) reflects a constrained motor system, because components of the movement are unable to appropriately compensate/correct for one another to successfully meet the task goal (Fietzer et al., 2018). It is thought that less functional movement variability was often caused by individuals who had a higher propensity for conscious control when executing the movement (van Ginneken et al., 2018). Consequently, engaging a higher level of conscious control is likely to breakdown these motor synergies, which diminishes the compensatory mechanisms of the motor system.

Implications for Practice

The present systematic review reaffirms the benefits of instructions that are designed to direct the performers attention to the effect of the movement (external focus) rather than the key components of the motor system producing the movement effect (internal focus) by spotlighting desirable movement characteristics that reflect more sophisticated organisation of movement. Put another way, this reflects a motor system that is less constrained through producing a more adaptable movement pattern to achieve the task goal. For practitioners, administering external focus instructions could induce more effective and efficient muscular activity that make athletes more resilient to physiological fatigue and muscle tension (Marchant et al., 2011). This would be particularly beneficial for athletes who are engaging in physiologically demanding activities that demand high levels of muscular endurance.

Coaches may be particularly attracted to the application of an external focus of attention instruction due to the suggestion that it invokes more functional variability in the motor system (Singh et al., 2022). As such, negative deviations in an earlier phase of the movement, which may occur naturally or by perturbation, such as physical contact from an opponent, may be corrected (or compensated) by adaptations in a later phase of the movement (Loosch & Müller, 1999). This may be important in sport related tasks which require the successful sequential coordination of multiple components of the motor system, like the mechanics of a tennis serve and the configuration of bodily components when jumping, balancing and running.

Nevertheless, internal focus of attention instructions still dominates the coaching of motor skills (Wulf, 2013; Yamada et al., 2022). In addition, when attempts are made to design external focus of attention instructions these are not always constructed appropriately. For instance, Chow et al. (2014) required participants to strike the foot in line with a virtual taped line when attempting to follow an external focus instruction. In this situation the reference to the foot may have caused participants to internalise their attention, since it proves difficult to differentiate between the movement and its associated effects. Moreover, the provision of some external focus instructions appear too vague. For example, Moore et al. (2019) provided the external focus instruction to "run quietly" (p. 1574), consequently this provision requires more task-specific instruction, as the participants perception of running quietly could vary in terms of its interpretation. Lastly, the context in which external focus instructions are provided should also be approached with caution. Particularly, this review found that markers of muscular activity did not differ in skilled participant populations (Calatayud et al., 2018a; Calatayud et al., 2018b; Halperin et al., 2016; Kristiansen et al., 2018). It is likely that skilled populations employ a focus of attention strategy that compliments their level of experience and/or skill (Couvillion & Fairbrother, 2018). Thus, attempts to follow a new focus of attention instruction may be challenging and, in some instances, may even disrupt task performance. Considering this, practitioners should be mindful of the benefits that an external focus carries, but not underestimate the complexity of constructing/phrasing these instructions and appropriately applying them if they wish to positively influence the organisation of movement characteristics.

Methodological Critique and Implications for Future Research

Measurements of The Organisation Movement Characteristics

The studies included in this review employed a variety of measures that capture different characteristics of movement organisation. Twenty-three studies used surface EMG to measure muscular activity from critical locations, which infer how well-organised the motor system was on a muscular level. Surface EMG electrodes which cover the skin of the muscle site can produce confounding results, as several muscles sites in a close proximity to one another can make it difficult to determine the specific muscle which the signal was transmitted from (Kristiansen et al., 2018). To counteract this, several studies in this review made adaptations to electrode placement by increasing the distance between the sites (Kristiansen et al., 2018; Marchant & Greig, 2017; Zachry et al., 2005) or by placement at distinctly different locations (Greig & Marchant, 2014; Hitchcock & Sherwood, 2018; Marchant et al., 2009; Vance et al., 2004). Forthcoming studies may wish to adopt these compromises to ensure accurate conclusions can be made on how attentional focus effects muscular activity when investigating movement directly.

Moreover, interpreting EMG has limitations, as surface EMG only provides patterns of activity across the muscles measured, it does not provide a comprehensive account of how force was generated or how the movement was organised. Considering this, coupling EMG with task-specific outcomes (e.g., force outputs, torques, accuracy, movement time) may best help interpret the efficiency and effectiveness of muscular activity. In addition, muscular co-contraction analysis may indicate how efficiently muscle groups worked together as synergies; generally, low levels of muscular co-contraction signify strong efficiency with minimal tension between opposing muscle groups. Employing kinematic data alongside EMG (e.g., joint angles, movement variability, velocity, acceleration) may infer whether excessive muscular activity was detrimental to the movement pattern more widely. Taking this into account, further work should consider employing these measures to enable a more comprehensive understanding of movement organisation,

In a similar vein, kinematic analysis has provided researchers with measures to understand movement characteristics directly. Commonly, single-joint measures are often employed as a means to capture JROM and single-joint variability within the motor system (Lohse et al., 2010). Whilst this is desirable, single-joint measures do not capture changes in the motor system more broadly, because only individual elements of the movement are captured, making it challenging to build assumptions about the organisational profile of the movement as a whole. Alternatively, some studies in this review have adopted multiple movement variability measures (Arruda et al., 2024; Fietzer et al., 2018; Lohse et al., 2014; Singh et al., 2022; Vidal et al., 2018; Waite et al., 2022), which are well-suited to capturing movement characteristics across the motor system, by identifying how key components interacted individually and collectively. Thus, future studies may wish to elect for multiple variability measures to make more conclusive claims on the influence focus of attention instructions have on the organisation of the movement more broadly.

Beyond this, some experimental work applied the uncontrolled manifold analysis (Fietzer et al., 2020; Singh et al., 2022) whereby the index of synergy was able to capture the quality of variability produced, and importantly researchers were able to identify the degree which elemental variables of the movement worked together. From a kinematic perspective movement variability provides the most insightful overview of the motor system, yet this only gives us the coordination and interaction of kinematics (e.g., joint ranges, angles and motions). The organisation of movement within the human body also encompasses the muscular system. Considering this, researchers should be cognisant that to explore how focus of attention directly influences the characteristics of movement, both the muscles and joints must be equally considered. In sum, the behavioural measures of movements have been measured in a variety of studies concerning attentional focus. However, the quantification of the constrained action hypothesis by much of the current experimental work would seem limited. Clearly this seems to be due to the inability to comprehensively capture the behavioural elements of movements that measure the muscles and joints in combination, which should be considered by future research.

Experimental Design

Notably, only 10 out of the 36 studies reviewed provided sample size estimations, to ensure the study is statistically powered. Indeed, a recent Bayesian meta-analysis by McKay et al. (2024) suggests that a large body of attentional focus research contains inadequate sample sizes. Subsequently, underpowered studies within the literature make it challenging to detect true effects within the data, and in cases can lead to exaggerated and overgeneralisation of certain findings (McKay et al., 2024). Moreover, many of the studies that reported sample size estimations provided no rationale for the effect size identified. Specifically, McKay et al. (2024) suggests after potential publication biases are considered, effect sizes within attentional focus appear to range from nil to trivial, at most. However, some studies in the literature have determined sample size estimations on effect sizes that are higher than this. Thus, effect estimates that are not representative of the current literature may lead to studies that are insufficiently powered and increase the chances of ambiguous findings. Critically, future research should employ sufficient sample size estimations and importantly, provide a rationalisation for effect sizes identified to enable well-powered studies that can support the findings produced.

Further, 33 out of the 36 studies employed a within-subject design. These experimental designs reduce the individual variance amongst groups, making it easier to detect important trends in movement-related data. However, the order of attentional focus conditions must be carefully considered when electing for a within-subject design. Most of the studies in this review counterbalanced internal and external focus of attention instructions across participants (n = 33), in which 14 of these studies contained a control condition. The control was often tested first in attempt to avoid biasing an individual's natural self-selected focus. It may be best to counterbalance all conditions since previous work investigating indirect markers of movement organisation (Becker & Hung, 2020) have employed a Latin Square design approach (equally alternating conditions), which allowed potential interaction effects of focus of attention and condition order to be considered. Alternating conditions in this way may be most appropriate, as the results of movement-related outcomes may be subject to the order of conditions. Thus, future within-subject experimental designs must be conscious of this to best manage carryover effects associated with task familiarisation or the focus of attention instructions administered.

Researchers should be mindful to how focus of attention instructions are designed to avoid confounding effects. Some studies may have provided instructions that inadvertently induced an internal focus via external focus instructions, and vice versa. For instance, Chow et al. (2014) intended to promote attention to the effect of the movement (an external focus) by asking participants to strike their foot in line with a virtual taped line. The mere reference to the foot, as well as the requirement of coupling it with the line, may have caused some participants to internalise their attention. It is important to consider how the user (e.g., participant or player) might interpret focus of attention instructions. Thus, it remains crucial for future research that instructions need to be developed that delineate focus on movement effects from the mechanics of the movement, as instructions which either reference the body or effects proximately related to key movements may cause participants internalise attention.

Moreover, it is essential to consider when designing studies to investigate the comparative effects of focus of attention instructions that one instructional set is not more attuned to task-relevant information than another. Herrebrøden, (2023) argued that this provides an explanation for the benefits of external focus instructions, particularly in far-aiming tasks. Although, internal focus instructions provide useful movement-related information this would relatively be irreplaceable by comparison to an external focus instruction (Herrebrøden, 2023). For instance, in a dart throwing task Lohse et al. (2014) encouraged an internal focus by stating “focus on the motion of your arms”, whereas an external focus specified “focus on the flight of the dart into the board” (p. 935). Thus, the external cue gives reference to two critical elements, firstly, the flight of the dart, drawing attention to the importance of trajectory, but also its destination by emphasising the task-goal. More broadly, focussing on the motion of the arms is more vague and more open to interpretation and trial and error; it is not an instruction that might have an immediate impact on performance of the task. It is a challenge to experimental designers to create internal and external focus of attention instructions that are equally task-specific and interpretable.

Research on attentional focus has also raised issues regarding adherence to prescribed instructions (Wulf et al., 2010b; Yamada et al., 2020; Zhuravleva & Aiken, 2023). Manipulation protocols were only employed by twelve studies to check if participants used their respective focus of attention instructions. The lack of manipulation checks adopted by studies means it remains challenging to determine how closely participants adhered to the instructions administered. Although a variety of measures used amongst studies to apprehend an individual's focus of attention (i.e., post-test questionnaires, episodic recalls and rating scales) offer insight into how a participant may have focussed, there is no conclusive method to determine where attention lies during task performance (Gray, 2004; Zhuravleva & Aiken, 2023). Further, the utilisation of interviews/questionnaires could confound the results, if participants were asked if they executed the movement using a particular focus of attention instruction, they may feel inclined to use this approach throughout the remaining trials. With this in mind, , manipulation protocols may simply wish to adopt verbal reports, which allow the participant to recollect how they executed the movement, without the experimenter mentioning specific focus of attention strategies that could further inflate the effect (Marchant et al., 2019). Adherence to instructions is likely down to participant preferences and/or familiarity. If the instruction is unpreferred, unfamiliar and/or difficult to interpret there is a higher chance that participants revert to an attentional focus strategy they are more acquainted with (Zhuravleva & Aiken, 2023). To maximise adherence and minimise the switching of focus, future studies should consider keeping instructions short and simple and frequently repeat the instruction.

Population Sample

Four experimental studies identified that organisation markers of muscular activity did not differ in resistance trained participant populations (Calatayud et al., 2018a; Calatayud et al., 2018b; Halperin et al., 2016; Kristiansen et al., 2018) and one study found an internal focus was better for enhancing muscular responses (Coratella et al., 2022). It was reported that all participants had amassed years of experience in resistance training, which was highly appropriate for the purposes of the task. It is plausible that the resistance trained participants may have adopted a focus of attention strategy that compliments their level of experience and/or skill (Couvillion & Fairbrother, 2018). Adherence to the relatively new focus of attention instructions may be difficult if the neural pathways were accustomed to executing the task using a particular focus of attention. Therefore, more skilled participants may be more immune to the consequences of an internal focus constraining the motor system due to extensive practice and skill development. More research is warranted to uncover whether attentional focus instructions directly influence the organisation of movement characteristics for individuals in highly skilled populations.

One of the criteria of this review was to exclude studies of participants who were injured or disabled. Conscious that broadening the criteria would make cross-comparison and synthesis of the findings challenging and the narrative convoluted, a focussed line of enquiry designed to capture key studies that directly answer the research question was preferred (Abrami et al., 1988). As a result, a known body of relevant empirical research from the domain of rehabilitation was not considered. This literature can meaningfully contribute to our understanding of the effect of focus of attention instruction on the organisation of human movement and therefore warrants further examination.

Conclusion

This is the first systematic review to directly examine how external and internal focus of attention instructions affect the organisation of movement of participants from healthy adult populations. In sum, compared to internal focus of attention instructions, external focus instructions resulted in muscular activity and kinematic profiles that are generally accepted as more desirable and reflective of a less constrained, more adaptable, better organised motor system. More specifically, the provision of external focus of attention instructions led to movements that enhanced JROM enabling more optimal configuration of joints, increased functional variability for a more adaptable motor system and reduced muscular activity aiding better movement efficiency. Considering the recommendations highlighted in the methodological critique, future work should aim to integrate muscular activity and movement kinematic measures that enable a more comprehensive understanding of movement organisation. Regarding experimental design, future research should employ sufficient sample size estimations for well-powered studies, counterbalance conditions to manage carryover effects and provide valid manipulation checks that don't confound the results. Lastly, researchers should carefully construct focus of attention instructions that avoid internally directing attention towards the movement. Ultimately, this review encourages researchers and practitioners alike to explore the focus of attention and movement organisation relationship further to aid motor development within different stages and contexts.

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Data availability statement

All data is provided in the manuscript for the systematic review.

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Supplementary Table 1

A Summary of the Study Characteristics: Focus of Attention Effects on Muscular Activation

Focus of Attention Effects on Muscular Activation for Force Generation Tasks									
Article	Sample	Experimental Design	Task	Focus Manipulation	Order of Conditions	Manipulation Checks	Movement Analysis	Outcome Measures	Result
Greig and Marchant (2014)	25 novice participants (male = 17; female = 8; *M age* = 23.50)	Within-subject	Isometric elbow flexion at three interchangeable speeds (60°, 180° and 300° s^{-1})	Internal: "focus upon the movement of your arm and muscles during the lift" (p. 138) External: "focus upon the movement of the crank hand-bar during the lift" (p. 138) Control: no specific instructions mentioned	Control followed by counterbalanced internal and external instructions	None	Muscular activation: EMG activity of bicep brachii. Captured and analysed muscular activity via Noraxon EMG software	Maximal force production (elbow flexor torque)	Outcome: EF > IF, C Note: Only at 60° Movement: EF > IF, C
Lohse and Sherwood (2012)	Exp 1 = 12 physically active participants (male = 6; female = 6) Exp 2 = 12 physically active (male = 5; female = 7)	Within-subject	Isometric planter-flexion task at three different target forces (30, 60 and 100% of maximal voluntary contraction)	Internal: "mentally focus on the contraction of the muscle in your calf. If you produce too much force, try to contract this muscle less. If you produce too little force, try to contract this muscle more" (p. 238) External: "mentally focus on the push of your foot against the platform. If you produce too much force, try to focus on pushing against the platform less. If you produce too little force, try to focus on pushing	Control followed by counterbalanced internal and external instructions	None	Muscular activation: EMG activity of the tibailas anterior and lateral aspect of the soleus. Captured and analysed muscular activity at muscles sites via a Biopac system / software for each maximal voluntary contraction target force	Force accuracy at 30, 60 and 100% maximal voluntary contraction Time to failure, at 30, 60 and 100%	Outcome: Exp1 Force accuracy EF > IF Exp2 Force accuracy EF = IF Time to failure EF = IF Movement overall: EF > IF

				against the platform harder" (p. 238)					
Lohse, Sherwood and Healy (2011)	12 novice participants (male = 6; female = 6)	Within-subject	Isometric force production task 30% of subject's maximum force	Internal: "focus on pushing with the muscle of their calf… If you produce too much force, try focus on contracting the muscle less. If you produce too little force focus on contracting the muscle more" (p. 176) External: "focus on the push of your foot against the platform… If you produce too much force, try to focus on pushing against the platform less. If you produce too little force, try to focus on pushing against the platform harder" (p. 176) Free-focus phase: "be as accurate as possible" (p. 176)	Counterbalanced internal and external instructions	Questionnaire: Four subjects adopted a purely external focus of attention; three subjects adopted a purely internal focus of attention; and five subjects adopted a mixture of the two	Muscular activation: EMG activity of soleus and tibailas anterior. Captured and analysed via Biopac hardware and software	Force production accuracy	Outcome: EF > IF Movement: Surface EMG EF > IF
Marchant and Greig (2017)	20 active participants (male = 16; female = 4; *M age* = 20.20)	Within-subject	Isokinetic knee extension at a speed of 60°s^{-1} over a 90° angle	Internal: "focussing on contracting the vastus medialis oblique whilst generating maximal effort" (p. 70) External: "Try to exert maximal effort during the movement, whilst pushing against the pad" (p. 70)	Counterbalanced internal and external instructions	None	Muscular activation: EMG activity of the vastus lateralis, vastus medialis oblique and rectus femoris. Captured and analysed muscular activity via Noraxon EMG software	Maximal force production	Outcome: EF = IF Movement: EF > IF
Marchant, Greig and Scott (2009)	25 novices (male = 16; female = 9;	Within-subject	Isokinetic elbow flexion maximal voluntary	Internal: "focus upon the movement of your arm	Control followed by counterbalanced internal and	Likert scale 1-7	Muscular activation:	Maximal force production	Outcome: EF > IF, C

	M age = 22.72)		contraction over 100° range of motion	and muscles during the lift" (p. 2361) External: "focus upon the movement of the crank hand bar during the lift" (p. 2361) Control: no specific instructions mentioned	external instructions	Rate the adherence to the instructions they were given. The following average ratings were observed EF = 3.58 IF = 3.13	EMG activity of the biceps brachii. Captured and analysed muscular activity via Noraxon EMG software	(elbow flexor torque)	Movement: EF > IF, C
Parr, Gallicchio, Canales-Johnson, Uiga and Wood (2023)	27 participants (male = 17; female = 10; *M age* = 23.76)	Within-subject	Isometric force precision task (hand dynamometer)	Internal: "For the next set of trials, care- fully focus on the contraction of your forearm muscles as you squeeze the dynamometer. Try and keep the contracted force line within the green boundary zone as accurately as possible whilst applying an equal amount of force across your index and middle fingers" (p. 4) External focus: "for the next set of trials, care-fully maintain your focus on the screen and the line being produced as you squeeze the dynamometer. Try and keep this line within the green boundary zone as accurately as possible" (p. 4)	Counterbalanced internal and external instructions	Questionnaire: allocation of attention toward external factors during the external focus condition. Likewise for internal focus.	Muscular activation: EMG activity of flexor carpi radialis and extensor carpi radialis of the right forearm. Captured and analysed via EEFLAB for MATLAB code software	Force Accuracy	Outcome: EF > IF Movement: EF > IF Note: only in flexor carpi radialis
Wulf, Dufek, Lozano and Pettigrew (2010)	8 active participants (male = 3; female = 5;	Within-subject	Vertical-jump and reach task a total of 10 vertical jumps were	Internal: "concentrate on the tips of their fingers" (p. 443)	Counterbalanced internal and	None	Muscular activation: EMG activity of the anterior tibialis, biceps femoris, vastus	Jump height and ground reaction forces	Outcome: Jump height EF > IF

	M age = 22.60)		performed in each condition	External: "concentrate on the rungs" (p. 443)	external instructions		lateralis, rectus femoris, gastrocnemius: EMG activity and onset times. Captured via Noraxon software, which was further synchronised with force platform data and analysed with BioWare software		Reaction forces EF > IF Movement: Onset EF = IF Surface EMG EF > IF Note: only in the vastus lateralis
Focus of Attention Effects on Muscular Activation for Strength Training Tasks									
Calatayud, Vinstrup, Jakobsen, Sundstrup, Colado, and Andersen (2018a)	18 resistance trained participants (male = 18; *M* = 31)	Within-subject	Bench press 50% of 1-repetition maximum	Internal triceps: "during this set, try focus on using your triceps muscles only" (p. 1164) Internal pectoralis: "during this set, try focus on using your chest muscles only" (p. 1164) External: "during this set, lift the barbell in a regular way" (p. 1164)	Counterbalanced internal and external focus instructions	None	Muscular activation: EMG activity of triceps and pectoralis. Captured and analysed muscular activity via Noraxon EMG software	None	Movement: Controlled Speed EF > IF Maximum Speed EF = IF
Calatayud, Vinstrup, Jakobsen, Sundstrup, Colado, and Andersen (2018b)	18 resistance trained participants (male = 18; *M* = 31)	Within-subject	Bench press 50% of 1-repetition maximum At grips widths of 100%, 150% and 200% of biacromial width distance	Internal triceps: "during this set, try focus on using your triceps muscles only" (p. 125) Internal pectoralis: "during this set, try focus on using your chest muscles only" (p. 125)	Counterbalanced internal and external focus instructions	None	Muscular activation: EMG activity of triceps and pectoralis. Captured and analysed muscular activity via Noraxon EMG software	None	Movement: EF = IF Suggested internal focus increased EMG, however this did not surpass significance

				External: "during this set, lift the barbell in a regular way" (p. 125)					
Coratella, Tornatore, Longo, Borrelli, Doria, Eposito and Cè (2022)	15 resistance trained participants (male = 15; *M* = 31)	Within-subject	Back-squat 50% and 80% of 1-repetition maximum	Internal focus: "focus on the posterior lower-limb muscles" (p. 431) External focus: "lift the barbell" (p. 431)	Counterbalanced internal and external focus instructions	None	Muscular activation: EMG activity of the gluteus maximus, biceps femoris gastrocnemius medialis, vastus lateralis, and tibialis anterior. Captured and analysed muscular activity via Noraxon FREEMG 300 software	None	Movement: Surface EMG Concentric Phase: IF > EF Note: gluteus maximus and bicep femoris greater with an internal focus. Further, reducing excitation of vastus lateralis Eccentric Phase: IF > EF Note: gastrocnemius medialis and tibialis anterior was greater with internal focus
Halperin, Hughes, Panchuk, Abbiss and Chapman (2016)	28 resistance trained participants (male = 14; female = 14; *M age* = 26.00)	Within-subject	Isometric elbow flexion over a 90° angle	Internal: "produce as much force as possible, focus on contracting your arm muscles as hard and as fast you can" (p. 5)	Control followed by counterbalanced internal and external instructions	None	Muscular activation: EMG activity of biceps brachii and triceps brachii. Captured and analysed via PowerLab software	Maximal force production	Outcome: EF > IF, MF, C Movement: EF = IF = MF = C

				External: "produce as much force as possible, focus on pulling the strap as hard and as fast you can" (p. 5) Mirror: "produce as much force as possible while looking at yourself in the mirror" (p. 5) Control: "produce as much force as possible" (p. 5)					
Kristiansen, Samani, Vuillerme, Madeleine and Hansen (2018)	21 resistance trained male participants (*M age*= 24.50)	Within-subject	Bench press, 60% of a participant's three-repetition maximum	Internal: "focus of attention should be on the contraction of your pectoral muscle. The contractions should be as smooth as possible" (p. 2444) External: "focus of attention should be on the movement of the barbell. The movement of the barbell should be as smooth as possible" (p. 2444) Control: No instruction	Control followed by counterbalanced internal and external instructions	10-point rating scale Rate the extent of adherence to the instructions. The following average ratings were reported: EF = 8.90 IF = 8.70	Muscular activation: EMG activity of the following 12 muscles: pectoralis, anterior deltoideus, triceps brachii lateral head, triceps brachii medial head, latissimus dorsi, erector spinae, rectus femoris, biceps femoris, gastrocnemius lateral head, soleus, vastus lateralis, and vastus medialis. Captured and analysed via Bioelectronica software	None	Movement: C > EF, IF
Neumann and Brown (2013)	24 novice females (*M age* = 21.40)	Within-subject	Sit-ups, 12 trials for each condition	Internal Association: focus on the abdominal muscles when performing the sit-up Internal Dissociation: participants asked to solve	Counterbalanced all internal external instructional groups	Likert scale 1-7 Rate the adherence to the instructions they were given. The following	Muscular activation: EMG activity of the abdominals and the hip. Captured and analysed via PowerLab software	Movement duration time	Outcome: IA = ID = EA = ED Movement: Range of movement

				an addition/subtraction task External Association: focus on trying to make smooth movements when performing the sit-up External Dissociation: participants were asked to follow a video clip and answer questions (See p. 10)		average ratings were observed Internal Association = 6.50 Internal Dissociation = 6.26 External Association = 6.52 External Dissociation = 6.54			EF(A) > EF(D), IF(s) Surface EMG EF(A) > EF(D), IF(A), IF(D)
Vance, Wulf, Töllner, Mcnevin and Mercer (2004)	Exp 1 = 11 weight-trained male participants (*M age* = 26.00) Exp 2 = 12 (male = 10; female = 2; age not reported)	Within-subject	Bicep curl at 50% of the participant's bilateral maximum force production over a 90° range of motion	Internal: "focus on the biceps when performing the task" (p. 452) External: "focus on the curl bar when performing the task" (p. 452)	Counterbalanced internal and external instructions	None	Muscular activation: EMG activity of the biceps brachii and triceps brachii. Captured via a P&G electrogoniometer and analysed with Noraxon Myoresearch software	None	Movement: Exp1 Surface EMG EF > IF Note: only in earlier repetitions Exp2 Surface EMG EF > IF

Focus of Attention Effects on Muscular Activation for Far-aiming Tasks

Hitchcock and Sherwood (2018)	24 novices (male = 16; female = 8; *M age* = 20.20)	Within-subject	Dart-throwing task with the dominant hand	Internal: "mentally focus on your elbow angle when they released the dart" (p. 1124)	Counterbalanced internal and external instructions	Scale: Rate the extent to which instructions were used, scale 1-6	Muscular activation: EMG activity of the biceps brachii and triceps brachii.	Throwing accuracy	Outcome: EF > IF Movement: Surface EMG

				External: "mentally focus on the flight of the dart" (p. 1124)		Manipulation check findings not specified	Captured and analysed muscular activity via a Biopac system		EF > IF
Lohse, Sherwood and Healy (2010)	12 novice participants (age and sex not reported)	Within-subject	Dart-throwing task with the dominant hand, aiming at a professional dartboard	Internal: "focus on the motion of your arm when throwing the dart and be as accurate as possible" (p. 548) External: "focus on the flight of the dart and be as accurate as possible" (p. 548)	Control followed by counterbalanced internal and external instructions	None	Muscular activation: Measurements of the biceps brachii and triceps brachii: EMG activity and onset times. Captured and analysed via Biopac hardware and software.	Throwing accuracy	Outcome: EF > IF Movement: Surface EMG EF > IF Note: only in triceps
Pelleck and Passmore (2017)	11 novice golf participants (male = 4; female = 7; *M age = 32.8*) 13 skilled golf participants (male = 12; female = 1; *M age = 33*.50)	Within-subject	Golf putting task	Internal-proximal: "focus on your hand gripping the club and the position of your elbows" (p. 25) Internal-distal: "focus on distributing your weight evenly through both feet" (p. 25) External: "focus on the target" (p. 25)	Counterbalanced internal and external instructions	None	Muscular activation: EMG activity of the tibialis anterior of the lower limb and the extensor carpi radialis of the upper limb. Captured via a CED 1902 dual system and analysed by a sweep-based data acquisition and analysis system.	Golf putting accuracy	Outcome: Novice EF > IF(P) > IF(D) Skilled EF = IF(P) = IF(D) Movement Surface EMG Upper Limb EF = IF(D) > IF(P) Note: only differences in novices in upper limb Lower limb

									IF(D) > EF = IF(P)
Zachry, Wulf, Mercer and Bezodis (2005)	14 novice basketball participants (male = 8; female = 6; *M age* = 26.20)	Within-subject	Basketball free-throw, 10 trials from a 15ft distance for each condition	Internal: "concentrate on the snapping motion of the wrist during the follow-through of the shot" (p. 306) External: "concentrate on the centre of the rear of the basketball hoop" (p. 306)	Counterbalanced internal and external instructions	None	Muscular activation: EMG activity of the flexor carpi radialis, biceps brachii, triceps brachii and deltoid of the shooting arm. Captured via a Noraxon MyoSystem unit and analysed with MATLAB software	Shot accuracy	Outcome: EF > IF Movement: EF > IF
Focus of Attention Effects on Muscular Activation for Speed/Movement Duration Tasks									
Kal, Van Der Kamp and Houdijk (2013)	31 novices (male = 11; female = 20; *M age*= 25.06)	Within-subject	Cyclic leg extension task in a seated chair positioned at a 90° angle	Internal: "focus on flexing and extending the leg" (p. 531) External: "focus on placing the foot in front of and behind the line" (p. 531)	Counterbalanced internal and external instructions	None	Muscular activation: EMG activity of the rectus femrois, vastus lateralis and semitendinosus. Captured and analysed via Optotrak and MATLAB software	Movement duration time	Outcome: EF > IF Movement: Surface EMG EF = IF
Kovacs, Miles and Baweja (2018)	12 collegiate track participants (male = 4; female = 8; *M age*= 20.80)	Within-subject	Sprint start from the blocks	Internal: "focus on extending your knees" (p. 3) External: "focus on pushing the blocks away" (p. 3)	Control followed by counterbalanced internal and external instructions	None	Muscular activation: EMG activity of the left and right vastus lateralis and the gastrocnemius. Captured via Delsys Trigno EMG systems and analysed with	Reaction time (Rear and front foot)	Outcome: Rear foot EF > IF, C Front foot EF, C > IF

				Control: No instruction			MATLAB code software		Movement: EF > IF, C
Focus of Attention Effects on Muscular Activation for Balance Tasks									
Ducharme and Wu (2015)	29 novice participants (male = 13; female = 16; *M* = 23.00)	Within-subject	Dynamic balance task	Internal focus: “focus on keeping your body over your feet” (p. 80) External focus: “focus on the surface you are walking on” (p. 80) Baseline: “Walk directly on the line towards the mark on the wall” (p. 79)	Counterbalanced internal and external focus instructions	None	Muscular activation: EMG activity of the peroneus longus, tibialis anterior, gastrocnemius lateralis, vastus medialis, and biceps femoris. Captured and analysed muscular activity via Noraxon EMG software	Lateral displacement	Outcome: EF > IF Movement: EF = IF

Note. Abbreviations: (D) = Distal focus; (P) = Proximal focus; MF = Mirror focus condition; (S) = Multiple focus of attention conditions; IA = Internal association; ID = Internal disassociation; EA = External association; ED = External disassociation; CC = Cognitive control condition; EMG = Electromyographic measurement; Exp = Experiment; > = Attentional focus condition was greater than another; = = Attentional focus condition was equal to another.

Supplementary Table 2

A Summary of the Study Characteristics: Focus of Attention Effects on Movement Kinematics for Movement Angles/Intersegmental Angles and Movement Variability

Focus of Attention Effects on Movement Kinematics for Movement Angles and Intersegmental Angles

Article	Sample	Experimental Design	Task	Focus Manipulation	Order of Conditions	Manipulation Checks	Movement Analysis	Outcome Measures	Result
Bull, Atack, North and Murphy (2023)	13 skilled male participants (*M age* = 35.50)	Within-subject	Cricket batting task (straight drives)	Internal: "focus on the movement of your hands" (p. 2050) External-proximal: "focus on the movement of your bat" (p. 2050) External-distal: "focus on the ball flight of your shot" (p. 2050) Control: no instruction was provided	Counterbalanced all instructions	None	Movement kinematics: Knee flexion angle and stride length. Captured by 2D video analysis and analysed with Kinovea software	Ball-bat contact for good contacts Ball-bat contact for miss/edges (bad contact)	Outcome: Good contact EF(D), EF(P) C > IF Note: only external distal and control significantly different from internal focus Bad contact EF(D), EF(P) C > IF Movement: Step length EF(D) C > EF(P) > IF Knee flexion EF(D) = C = EF(P) = IF

Chow, Woo and Koh (2014)	16 novice participants (male = 9; female = 7; *M age* = 19.60)	Between-subject	Running transition from a heel-foot to a forefoot strike pattern	Internal: "focus on putting weight on the ball of your feet AND push off using the ball of your feet" (p. 311) External: "focus on landing with the coloured section of the shoe AND strike the foot in line with the virtual line" (p. 311)	Not applicable	Interview Manipulation check findings not specified	Movement kinematics: Angle of the ankle; calcaneus displacement; and forefoot strike. Captured via Hawk motion software and analysed with Visual 3D	None	Practice and retention test results Movement: IF = EF
de Arruda, Dai, Readdy, Mcrea and Zhu (2024)	32 female participants: 16 novices (*M age* = 24.75) and 16 skilled volleyball players (*M age* = 20.25)	Within-subject	Simulated volleyball setting task	Internal: "Remember to place the right foot forward, bend your knees, and also to position your fingers in front of the forehead spread and forming a round shape. The thumbs and index fingers should form a triangle. As you contact the ball, be sure to extend both your arms and legs in the direction of the intended set. Finally, it is important to feel that your hands, arms, and legs are moving elastically like a spring" (p. 30) External: "Remember to take a step over the floor tape and lower your eye height, allowing you to see through the taped window formed by blue and red tapes on the target while searching for the ball. Once the ball is located in the triangle	Control followed by counterbalanced internal and external instructions	Rating scale Likert scale 0-5	Movement kinematics: Elbow and knee flexion/extension angles. Inter-joint coordination through flexion/extension of the two elbows and knees on both sides. Variability of inter-joint coordination also assessed. The analysed movement started at the frame of movement initiation and ended 10 frames after the ball's release. Captured via Peak Performance Motion software and analysed with MATLAB code	Accuracy, speed, angle of release and elbow flexion angles at ball contact	Outcome: Skilled participants outperformed novices Skilled C > EF, IF Note: only for setting accuracy Novice: EF = IF = C Movement: Skilled participants developed better movement patterns than novices

				formed by your raised hands, reach to make contact with the ball as high as possible, be sure to follow through in direction to the target. Finally, try to find the best ball trajectory to reach the target” (p. 30) Control: : no specific instructions mentioned					Inter-joint coordination: EF = IF = C Variability of inter-joint coordination: EF, IF > C Note: Reduced variability only regarded as beneficial for novices, detrimental for skilled participants
Harry, Lanier, Nunley and Blinch (2019)	22 active participants (male = 11; female = 11; *M age* = 22.50)	Within-subject	Countermovement jump landing task	Internal: “after contacting the highest rung concentrate on flexing your knees as rapidly as possible upon ground contact” (p. 3) External: “after contacting the highest rung, concentrate on pushing against the ground as rapidly as possible upon ground contact” (p. 3)	Counterbalanced internal and external instructions	None	Movement kinematics: Angles/joint contributions (joint moments and angular work) of the trunk, hip, knee and ankle. Captured via Vicon motion analysis software and processed/analysed using Visual 3D and MATLAB software	Landing-jump height and ground reaction forces upon landing	Outcome: Jump height EF > IF Reaction forces EF = IF Movement: EF > IF
Lohse, Jones, Healy and Sherwood (2014)	15 novice participants (male = 9; female = 6; age not reported)	Within-subject	Dart-throwing task with the dominant hand	Internal-proximal: “focus on the motion of your arm” (p. 935)	Counterbalanced all internal external instructional groups	None	Movement kinematics: Joint angle and velocity at the shoulder, elbow and wrist of the throwing arm, as well as trial-to-trial	Throwing accuracy	Outcome: EF(s) > IF(s), C Movement: EF(s) > IF(s), C

				Internal-distal: "focus on the dart leaving your hand" (p. 935) External-proximal: "focus on the flight of the dart into the board" (p. 935) External-distal: "focus on the bull's-eye" (p. 935) Control: "be as accurate as possible" (p. 935)			variability within each dependent variable. Captured and analysed via Dartfish ConnectPro motion-analysis software		
Lohse, Sherwood and Healy (2010)	12 novice participants (age and sex not reported)	Within-subject	Dart-throwing task with the dominant hand	Internal: "focus on the motion of your arm when throwing the dart and be as accurate as possible" (p. 548) External: "focus on the flight of the dart and be as accurate as possible" (p. 548)	Control followed by counterbalanced internal and external instructions	None	Movement kinematics: Angle of shoulder, elbow flexion measured at the moment of retraction and at the moment of release; angular velocity of the dart measured upon release. Captured and analysed via Dartfish ConnectPro software	Throwing accuracy	Outcome: EF > IF Movement: Kinematics EF > IF Note: only at shoulder
Mazza, Cimo, Valenzuela and Wu (2022)	41 novice participants (male = 21; female = 20)	Between-subject	Standing Long Jump	Internal: "told to jump as far as they could and think about extending their knees as fast as possible" (p. 1475) External: "told to jump as far as they could and think about jumping as close to the chair as they could" (p. 1475)	Not applicable	None	Movement kinematics: peak hip flexion, peak knee flexion, peak ankle dorsiflexion, and tibial projection angle at time of toe off. Captured via Qualisys Motion software and analysed with MATLAB code. Ground reaction forces	Jump distance and ground reaction forces	Outcome: EF = IF = C Movement: EF, C > IF Note: only in tibial projection angle

				Control: "told to jump as far as they could" (p. 1475)			were captured via Bertec force platform software		
Moore, Phillips, Ashford, Mullen, Groom and Gittoes (2019)	28 Recreational Runners (male = 22; female = 6; *M age* = 24.90)	Between-subject	Running gait retraining a flatter foot angle	Internal: "run with a flat foot" (p. 1574) External: "run quietly" (p. 1574) Clinical: "we are aiming to change foot strike, so run quietly" (p. 1574)	Not applicable	Likert scale 1-6 96% an adherence score ≥ 4 and the final participant reporting a three	Movement kinematics: Joint angles of the knee and ankle at contact. Captured and analysed via CODAmotion software		Movement: Foot angle IF > CLIN > EF Knee angle: EF = CLIN > IF Note: Despite greater knee angle in EF minimal changes in ankle angle meant a flatter foot strike was not generated
Schutts, Wu, Vidal, Hiegel and Becker (2017)	12 trained participants (male = 8; female = 4; *M age* = 23.40)	Within-subject	Snatch lift at 80% of the participant's one-repetition maximum	Internal: "concentrate on how the lifter is able to move his elbows high and to the side" (p. 2761) External: "concentrate on how the lifter is able to move the barbell back and up" (p. 2761)	Counterbalanced internal and external instructions	None	Movement kinematics: Barbell cervical hip angles and velocity. Captured via Qualisys Motion software and analysed with Qualisys Track Manager	None	Movement: EF > IF
Vidal, Wu, Nakajima and Becker (2018)	20 active participants (male = 10; female = 10; *M age* = 22.00)	Within-subject	Standing long jump, a total of 10 jumps were performed in each condition	Internal: "jump as far as you can. While jumping think about extending your knees as rapidly as possible" (p. 530) External: "jump as far as you can. While jumping, think about jumping as	Counterbalanced internal and external instructions	Questionnaire: Report of focus after each jump Manipulation check findings not specified	Movement kinematics: Joint angles at the ankle, knee and hip. Coordination variability was quantified by a modified vector coding	Jump distance	Outcome: EF > IF Movement: EF > IF Joint angles EF > IF

				close to the orange cones as possible” (p. 530)			technique between the ankle-knee and knee-hip intersegmental angles during the downward phase (start to time before peak knee flexion) transition phase (end of the downward phase until peak knee flexion) and the take-off phase (end of transition phase until take off) Captured via Qualisys Motion software and analysed with Visual 3D and LabView software		Variability No differences
Waite, Sackiriyas, Jaywickrema, and Almonroeder (2022)	16 active female participants (*M age* = 21.80)	Within-subject	Drop landing task	Internal: “focus on bending your knees when you land” (p. 688) External: “focus on landing softly” (p. 688) Control: “Use typical landing technique” (p. 688)	Counterbalanced internal and external instructions	None	Movement kinematics: hip-knee, hip-ankle and knee-ankle angle pairings. Coordination variability was quantified by a modified vector coding technique between them. Captured via Vicon motion software and analysed with Vicon Tracking software	None	Movement: Angle Pairings EF = IF = C Variability EF > IF, C Note: not significant in the hip-knee angle

Focus of Attention Effects on Movement Kinematics for Movement Variability

de Arruda, Dai, Readdy, Mcrea and Zhu (2024)	32 female participants: 16 novices (*M age* = 24.75) and 16 skilled volleyball players (*M age* = 20.25)	Within-subject	Simulated volleyball setting task	Internal: “Remember to place the right foot forward, bend your knees, and also to position your fingers in front of the forehead spread and forming a round shape. The thumbs and index fingers should form a triangle. As you contact the ball, be sure to extend both your arms and legs in the direction of the intended set. Finally, it is important to feel that your hands, arms, and legs are moving elastically like a spring” (p. 30) External: “Remember to take a step over the floor tape and lower your eye height, allowing you to see through the taped window formed by blue and red tapes on the target while searching for the ball. Once the ball is located in the triangle formed by your raised hands, reach to make contact with the ball as high as possible, be sure to follow through in direction to the target. Finally, try to find the best ball trajectory to reach the target” (p. 30)	Control followed by counterbalanced internal and external instructions	Rating scale Likert scale 0-5	Movement kinematics: Elbow and knee flexion/extension angles. Inter-joint coordination through flexion/extension of the two elbows and knees on both sides. Variability of inter-joint coordination also assessed. The analysed movement started at the frame of movement initiation and ended 10 frames after the ball’s release. Captured via Peak Performance Motion software and analysed with MATLAB code	Accuracy, speed, angle of release and elbow flexion angles at ball contact	Outcome: Skilled participants outperformed novices Skilled C > EF, IF Note: only for setting accuracy Novice: EF = IF = C Movement: Skilled participants developed better movement patterns than novices Inter-joint coordination: EF = IF = C Variability of inter-joint coordination: EF, IF > C

				Control: : no specific instructions mentioned					Note: Reduced variability only regarded as beneficial for novices, detrimental for skilled participants
Fietzer, Winstein, and Kulig (2018)	35 novice participants (male = 15; female = 20; *M age* = 30.00)	Within-subject	Unipedal hopping, across both legs	Internal: “hop in place, focus on your toe landing in the same place every time” (p. 17) External: “hop in place focus on landing on the tape target every time” (p. 17) Control: “please hop in place” (p. 17)	Control followed by counterbalanced internal and external instructions	Questionnaire EF = 100% focussed on the external focus instructions IF = 100% focussed on the internal focus instructions Control = 58% in time to the beat; 27% focussed on hopping in the same place; 12% focussed on the hopping technique; and 3% focussed on other aspects	Movement kinematics: Measurements of leg orientation (leg position relative to the centre of mass) at take-off/landing and vertical leg-length in the stance phase. This was captured by analysing foot-to-floor, and ankle and knee intersegmental angles to afford analysis of movement variability of these aspects using the uncontrolled manifold (UCM) and synergy index (IOS) Captured via Qualisys Motion software and analysed with MATLAB code	Hop error	Outcome: EF > IF, C Movement: UCM and IOS analysis Leg-orientation EF > IF, C Leg-length EF > IF > C
Howard, Arend, Van Gemmert and Kuznetsov (2023)	38 novice participants (male = 7; female = 31;	Within-subject	Planar reaching task	Internal: “focus on extending your elbow” (p. 5)	Control followed by counterbalanced internal and	Recall compliance form Control = 50% reported adopting	Movement kinematics: measurements of the dominant and non-dominant arm at manubrium, acromion	Endpoint accuracy and magnitude of pointing variability	Outcome: EF > IF Note: the authors only discussed

	M age = 22.00)			`External: "focus on hitting the target marker with the dowel endpoint" (p. 5) Control: "complete the task as best as you can" (p. 5)	external instructions	an external focus, 5% internal focus and 45% reported a mix. EF: 85% adopted an external focus, 5% adopted an internal focus, while 10% reported a mix IF: 84% reported an internal focus, while 16% used a mix	process, lateral epicondyle, and radial styloid process. This was used to analyse the joint angles and movement variability of clavicle-scapular complex, shoulder, elbow flexion, and wrist.		the results with regards to external and internal focus. Movement: UCM and IOS analysis EF > IF
Lohse, Jones, Healy and Sherwood (2014)	15 novice participants (male = 9; female = 6; age not reported)	Within-subject	Dart-throwing task with the dominant hand	Internal-proximal: "focus on the motion of your arm" (p. 935) Internal-distal: "focus on the dart leaving your hand" (p. 935) External-proximal: "focus on the flight of the dart into the board" (p. 935) External-distal: "focus on the bull's-eye" (p. 935) Control: "be as accurate as possible" (p. 935)	Counterbalanced all internal external instructional groups	None	Movement kinematics: Joint angle and velocity at the shoulder, elbow and wrist of the throwing arm, as well as trial-to-trial variability within each dependent variable. Captured and analysed via Dartfish ConnectPro motion-analysis software	Throwing accuracy	Outcome: EF(s) > IF(s), C Movement: EF(s) > IF(s), C
Singh, Shih, Kal, Bennett and Wulf (2022)	20 trained volleyball participants (male = 7; female= 13;	Within-subject	Volleyball Serve	Internal: "focus on your hand while contacting the ball" (p. 4)	Counterbalanced internal and external instructions	None	Movement kinematics: Measurements of shoulder, elbow and wrist joint angles to	Throwing accuracy	Outcome: EF(D) > EF(P) = IF Movement:

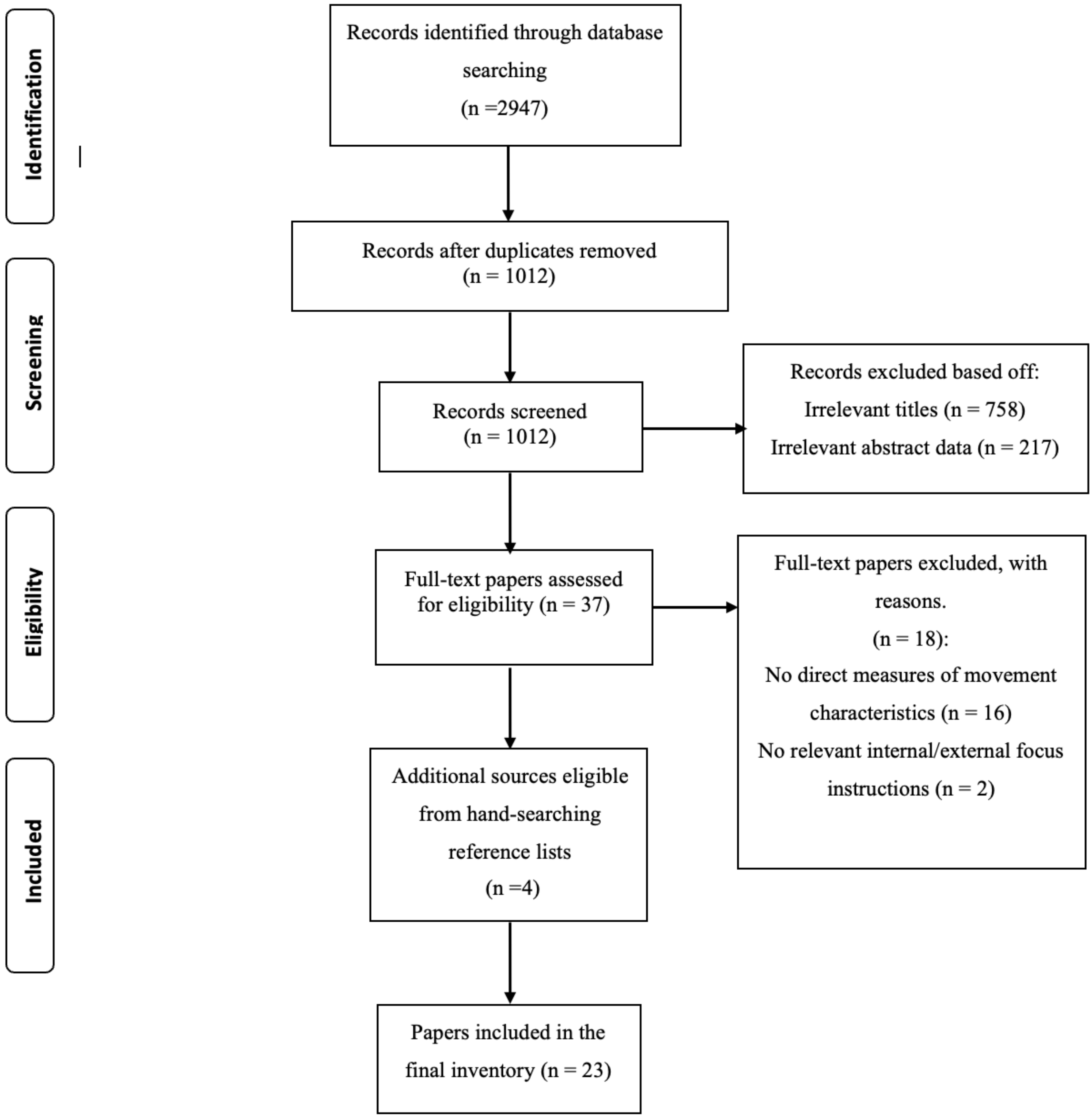
	M age = 25.20)			External-proximal: "focus on contacting the middle of the ball" (p. 4) External-distal: "focus on hitting the bullseye"			assess movement variability. This was captured by analysing joint angles using the uncontrolled manifold (UCM) and index of synergy (IOS) to see what degree these variables worked together (functional variability) Captured via Vicon Motion software and analysed with MATLAB code		UCM analysis EF(D) > EF(P) = IF IOS EF(D) > EF(P) > IF
Vidal, Wu, Nakajima and Becker (2018)	20 active participants (male = 10; female = 10; *M age* = 22.00)	Within-subject	Standing long jump, a total of 10 jumps were performed in each condition	Internal: "jump as far as you can. While jumping think about extending your knees as rapidly as possible" (p. 530) External: "jump as far as you can. While jumping, think about jumping as close to the orange cones as possible" (p. 530)	Counterbalanced internal and external instructions	Questionnaire: Report of focus after each jump Manipulation check findings not specified	Movement kinematics: Joint angles at the ankle, knee and hip. Coordination variability was quantified by a modified vector coding technique between the ankle-knee and knee-hip intersegmental angles during the downward phase (start to time before peak knee flexion) transition phase (end of the downward phase until peak knee flexion) and the take-off phase (end of transition phase until take off)	Jump distance	Outcome: EF > IF Movement: EF > IF Joint angles EF > IF Variability No differences

							Captured via Qualisys Motion software and analysed with Visual 3D and LabView software		
Waite, Sackiriyas, Jaywickrema, and Almonroeder (2022)	16 active female participants (*M age* = 21.80)	Within-subject	Drop landing task	Internal: “focus on bending your knees when you land” (p. 688) External: “focus on landing softly” (p. 688) Control: “Use typical landing technique” (p. 688)	Counterbalanced internal and external instructions	None	Movement kinematics: hip-knee, hip-ankle and knee-ankle angle pairings. Coordination variability was quantified by a modified vector coding technique between them. Captured via Vicon motion software and analysed with Vicon Tracking software	None	Movement: Angle Pairings EF = IF = C Variability EF > IF, C Note: not significant in the hip-knee angle

Note. Abbreviations: (D) = Distal focus; (P) = Proximal focus; (S) = Multiple focus of attention conditions; CLIN = Clinical Condition; Exp = Experiment; > = Attentional focus condition was greater than another; = (=) Attentional focus condition was equal to another.

Supplemental Material 2

Figure Showing Stages and Results of the Initial Search process Using the PRISMA Guideline Framework: Adapted from Moher et al. (2015)



Supplemental Material 3

Quality Assessment Items Table

Item Number	Item
1	Is the hypothesis/aim/objective of the study clearly described?
2	Have the authors established a theoretical framework for the study?
3	Is the study design clearly described and appropriate to test the hypotheses?
4	Are the main outcomes to be measured clearly described?
5	Are the characteristics of participants in the study clearly described?
6	Are the subjects asked to participate in the study representative of the entire population from which they were recruited?
7	Are details of sample size determination included?
8	Is there evidence of attention to ethical issues?
9	Is the experimental task clearly described?
10	Were the statistical tests used to assess the main outcomes appropriate?
11	Does the study provide estimates of the statistical parameters (e.g., regression coefficients)?
12	Have actual probability values been reported for the main outcomes, except where the probability value is less than 0.001?
13	Are effect sizes consistently reported?
14	Are conclusions substantiated by the data that are presented in the results?
15	Are the main findings of the study clearly described?
16	Can the study results be applied to other relevant populations?
17	Are results adequately compared to previous studies and in relation to theoretical frameworks?
18	Are the methods of assessing the outcome variables valid?

Note. Items were taken from (DuRant, 1994), the Quality Index (Downs & Black, 1998) and the Epidemiological appraisal Instrument (Genaidy et al., 2007). 8a: Additional item to verify attention to ethics (Spencer, Ritchie, Lewis, & Dillon, 2003). Similar to approaches used by systematic reviews in the field of sport science, to ensure a comprehensive quality assessment of the included studies (Harris et al., 2021).

Supplemental Material 4

Quality Assessment Scores Table

Article	Items																		Total		Comments
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	*Raw*	%	
Bull, Atack, North and Murphy (2023)	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	16	89	Sample was only representative of skilled cricket players who were male, with no female participants present within the study. Sample characteristics make it difficult to generalise study results to other populations.
Calatayud, Vinstrup, Jakobsen, Sundstrup, Colado, and Andersen (2018a)	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1	15	83	No inclusion of sample size determination using G-power. In addition, sample was only representative of resistances trained males, with no female participants present within the study. Sample characteristics make it difficult to generalise study results to other populations.
Calatayud, Vinstrup, Jakobsen, Sundstrup, Colado, and Andersen (2018b)	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	15	83	No inclusion of sample size determination using G-power. In addition, sample was only representative of resistances trained males, with no female participants present within the study. Sample characteristics make it difficult to generalise study results to other populations.
Coratella, Tornatore, Longo, Borrelli, Doria, Eposito and Cè (2022)	1	0	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1	14	78	Sample was only representative of resistance trained males, with no female participants present within the study. Sample characteristics make it difficult to generalise study results to other populations. Theoretical framework should be considered, seems an unfair comparison to compare an external focus against an internal focus on particular muscles when investigating hypertrophic responses. Moreover, hypertrophic may not mean more effective and efficient movement, which could be key to resistance training exercises.
Chow, Woo and Koh (2014)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.

de Arruda, Dai, Readdy, Mcrea and Zhu (2024)	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	16	89	Sample was only representative of female participants, with no male participants present in the study. Sample characteristics make it difficult to generalise study results to other populations.
Ducharme and Wu (2015)	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.
Fietzer, Winstein, and Kulig (2018)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	17	94	Results adequately compared to other literature within the filed. However, greater reference to the prominent theoretical framework of the constrained action hypothesis should be used to support results.
Greig and Marchant (2014)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.
Halperin, Hughes, Panchuk, Abbiss and Chapman (2016)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.
Harry, Lanier, Nunley and Blinch (2019)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	100	
Hitchcock and Sherwood (2018)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power. In addition, manipulation check findings were not specified.
Howard, Arend, Van Gemmert and Kuznetsov (2023)	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	16	89	Sample was only representative of female participants with only 7 of the 38 participants reported as male. Sample characteristics (7 males) make it difficult to generalise study results to other populations.
Kal, Van Der Kamp and Houdijk (2013)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.
Kovacs, Miles and Baweja (2018)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.

Kristiansen, Samani, Vuillerme, Madeleine and Hansen (2018)	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1	15	83	No inclusion of sample size determination using G-power. In addition, sample was only representative of resistances trained males, with no female participants present within the study. Sample characteristics make it difficult to generalise study results to other populations.
Lohse and Sherwood (2012)	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	14	78	No inclusion of sample size determination using G-power. In addition, no age range of the participants provided or mean age data for participants. Thus, difficult to determine whether study results are representative and can be applied to other relevant populations with missing information on age-related data.
Lohse, Sherwood and Healy (2010)	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	14	78	No inclusion of sample size determination using G-power. In addition, no age range of the participants provided or mean age data for participants. Thus, difficult to determine whether study results are representative and can be applied to other relevant populations with missing information on age-related data.
Lohse, Jones, Healy, and Sherwood (2014)	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	14	78	No inclusion of sample size determination using G-power. In addition, no age range of the participants provided or mean age data for participants. Thus, difficult to determine whether study results are representative and can be applied to other relevant populations with missing information on age-related data.
Lohse, Sherwood and Healy (2011)	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	14	78	No inclusion of sample size determination using G-power. In addition, no age range of the participants provided or mean age data for participants. Thus, difficult to determine whether study results are representative and can be applied to other relevant populations with missing information on age-related data.
Marchant, Greig, and Scott (2009)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.
Marchant and Greig (2017)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.

Mazza, Cimo, Valenzuela and Wu (2022)	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	1	1	15	83	No inclusion of sample size determination using G-power. . In addition, no age range of the participants provided or mean age data for participants. Thus, difficult to determine whether study results are representative and can be applied to other relevant populations with missing information on age-related data.
Moore, Phillips, Ashford, Mullen, Groom and Gittoes (2019)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	100	
Neumann and Brown (2013)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power. Purposefully specified all female cohort so representative of the population but makes generalisability to other populations challenging.
Parr, Gallicchio, Canales-Johnson, Uiga and Wood (2023)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	100	
Pelleck and Passmore (2017)	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	16	89	No inclusion of sample size determination using G-power. In addition, the sample characteristics of skilled golfers only included one female participant. Thus, more needed for accurate representation.
Schutts, Wu, Vidal, Hiegel and Becker (2017)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.
Singh, Shih, Kal, Bennett and Wulf (2022)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	100	
Waite, Sackiriyas, Jaywickrema, and Almonroeder (2022)	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1	15	83	No inclusion of sample size determination using G-power. In addition, sample was only representative of active females, with no male participants present within the study. Sample characteristics make it difficult to generalise study results to other populations.

Vance, Wulf, Töllner, Mcnevin and Mercer (2004)	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	14	78	No inclusion of sample size determination using G-power. In addition, no age range of the participants provided or mean age data for participants in experiment 2. Sample was only representative of resistances trained males in experiment 1, and only two female participants in experiment 2. Thus, difficult to generalise study results to other populations.
Vidal, Wu, Nakajima and Becker (2018)	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.
Wulf, Dufek, Lozano and Pettigrew (2010)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.
Zachry, Wulf, Mercer and Bezodis (2005)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	17	94	No inclusion of sample size determination using G-power.