Elastic Band Training Enhances Sprint Acceleration, Change of Direction, and Throwing Performance in Handball Players: A Mechanistic Scooping Review

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Abstract

Handball performance requires short-distance acceleration, rapid change of direction, jumping ability, upper limb strength, and high-velocity throwing; however, the effectiveness of elastic band training for these sport-specific components still requires careful synthesis. This study aimed to examine the effects of elastic band training on sprint acceleration, change of direction, jump performance, upper-limb strength, and throwing-related performance in competitive handball players. A scooping review with structured narrative synthesis was conducted following PRISMA 2020 guidance. Articles published between 2016 and 2025 were searched in Scopus, PubMed, Web of Science, and Google Scholar. Of the 51 records identified, 12 studies involving approximately 359 handball players met the inclusion criteria. Most participants were youth, adolescent, or junior players. The interventions lasted 6-10 weeks and were implemented two to three sessions per week. The synthesis showed that elastic band training was generally associated with improvements in short-distance sprint acceleration, change of direction, selected jump outcomes, upper-limb strength, and throwing-related performance. Change of direction demonstrated the most consistent positive pattern, whereas jump outcomes were more variable across protocols. This review concludes that elastic band training can be considered a practical complementary modality for handball conditioning, particularly among young players. Nevertheless, the physiological and biomechanical mechanisms underlying these performance changes remain inferential and require direct confirmation through future experimental studies.

Keywords: Elastic Band Training; Handball; Sprint Acceleration; Change of Direction; Youth Athletes.

INTRODUCTION

Team handball is an intermittent invasion sport in which performance is shaped by the repeated execution of high-intensity actions under spatial, temporal, and tactical pressure. During competition, players must accelerate over short distances, decelerate, change direction, jump, tolerate body contact, and complete high-velocity throwing actions within a restricted playing area. These requirements make handball performance a multidimensional construct rather than a single expression of general fitness. Match-based evidence has shown that elite handball imposes substantial physical and physiological demands, with performance depending on repeated explosive movements, position-specific locomotor profiles, and fatigue-related reductions in match actions (Karcher & Buchheit, 2014; Michalsik et al., 2012; Póvoas et al., 2012). Throwing performance also depends on coordinated upper-body kinematics and the transfer of force through the trunk, shoulder, and arm, indicating that upper-limb strength and technical sequencing are integral to sport-specific execution (Wagner et al., 2014). Within this context, resistance-oriented preparation has become important because muscular strength and power are associated with key handball outcomes such as sprinting, jumping, and throwing (Chelly et al., 2014; Hermassi et al., 2011; Suchomel et al., 2016). Therefore, any training method proposed for handball should be evaluated in relation to the sport's combined lower-limb and upper-limb demands, particularly sprint acceleration, change of direction, jump performance, upper-limb strength, and throwing-related performance.

Despite the importance of resistance training for handball preparation, the practical design of training remains a relevant problem, especially for youth, adolescent, and junior players. Conventional resistance methods, including free weights, machines, and plyometric drills, may improve strength and power, but their use can be constrained by equipment availability, technical supervision, maturation status, training time, and the need to manage mechanical loading in developing athletes. Elastic band training (EBT) has been proposed as a practical complementary modality because elastic resistance is portable, inexpensive, scalable, and capable of creating variable resistance as band tension increases with elongation (Wilson & Kritz, 2014). Broader systematic evidence indicates that elastic resistance can improve muscular strength and functional performance across populations, although such findings cannot be transferred directly to handball without considering the sport's distinctive movement and throwing demands (Colado et al., 2020; Lopes et al., 2019). Empirical handball studies also suggest that elastic-band interventions may improve shoulder strength, throw velocity, or select lower-limb performance outcomes, but these effects are not consistent across all protocols or variables (Aloui, Hermassi, et al., 2019a; Andersson et al., 2018a; Mascarin et al., 2017). This problem is important because coaches require evidence-informed methods that are feasible in applied settings while still relevant to sport-specific outcomes. The problem occurs partly because EBT protocols differ in duration, loading description, exercise selection, body-region emphasis, and comparator condition. It can be addressed through a scooping synthesis that distinguishes observed performance effects from mechanisms that remain inferential.

The novelty of the present review lies in its focused synthesis of EBT evidence within competitive handball and its explicit separation of reported performance outcomes from unverified mechanistic explanations. Previous work has examined EBT in handball, but most studies have been conducted as individual interventions with limited samples, specific sex or age groups, and selected outcome domains. For example, lower-limb elastic-band programs have examined sprint, change of direction, and jump outcomes in junior male players, whereas upper-limb protocols have emphasized strength or throwing-related variables (Aloui, Hammami, et al., 2019; Aloui, Hermassi, et al., 2019a; Aloui et al., 2020, 2021). Studies involving young female players have extended the evidence base by examining combined upper- and lower-limb elastic-band programs and outcomes related to sprinting, change of direction, jumping, power, and strength (Gaamouri et al., 2023, 2024; Hammami, Gaamouri, Cherni, et al., 2022; Hammami, Gaamouri, Wagner, et al., 2022). However, the available literature remains fragmented because studies differ in intervention length, weekly frequency, band-intensity reporting, exercise focus, and performance tests. Some studies also report improvements in selected domains while showing unchanged results in others, suggesting that EBT effects should not be generalized across all handball performance components. The research gap, therefore, is not the absence of EBT studies, but the absence of a domain-based synthesis that clarifies where the evidence is more consistent, where it remains variable, and which explanations are supported directly by measured outcomes. This review addresses that gap by organizing the evidence around sprint acceleration, change of direction, jump performance, upper-limb strength, and throwing-related performance.

Accordingly, this scooping review aimed to synthesize the available evidence on the effects of EBT on sport-specific performance outcomes in competitive handball players. The review focused on controlled intervention studies involving handball players who completed elastic-band, resistance-band, TheraBand, elastic-tubing, or rubber-band training lasting at least five weeks and reported at least one relevant performance outcome. The scope was limited to handball players to reduce the interpretive risk of drawing conclusions from mixed-sport, non-athlete, or clinical populations. The analysis was directed toward four major outcome domains: sprint acceleration, change of direction or agility, jump performance, and upper-limb strength or throwing-related performance. This scope also recognizes an important limitation: the review can summarize observed changes in field-based performance tests, but it cannot confirm physiological or biomechanical mechanisms unless those mechanisms were directly measured in the included studies. Therefore, explanations related to rate of force development, eccentric braking, stretch-shortening cycle efficiency, neuromuscular coordination, and kinetic-chain transfer are treated as plausible interpretations rather than definitive causal evidence. By clarifying the domain-specific effects and methodological boundaries of EBT, this review is expected to support more cautious application of elastic resistance in handball conditioning and to guide future trials toward standardized intensity reporting, stronger experimental designs, and direct biomechanical or neuromuscular measurement.

METHODS

Research Design

This study was designed as a scooping review with structured narrative synthesis. The review did not use a primary experimental, survey, correlational, or ex post facto design because its unit of analysis was not an individual athlete recruited directly by the authors, but published intervention studies that examined elastic band training (EBT) in handball. The design was appropriate because the objective was to synthesize and critically organize evidence on the effects of EBT on sport-specific performance outcomes, including sprint performance, change of direction (COD), jump performance, upper-limb strength, and throwing-related performance. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses framework to improve transparency in study identification, screening, eligibility assessment, and reporting (Page et al., 2021).

A structured narrative synthesis was selected instead of meta-analysis because the included studies differed in participant characteristics, training duration, weekly frequency, band-intensity reporting, exercise selection, comparator conditions, and performance tests. The supplied manuscript also indicates that the extracted studies did not consistently report effect sizes, confidence intervals, exact p-values, or comparable pre-post numerical data. Therefore, a narrative approach allowed the evidence to be organized by performance domain while avoiding unsupported quantitative pooling. Mechanistic explanations, such as rate of force development, eccentric braking, stretch-shortening cycle function, and kinetic-chain transfer, were treated as interpretive explanations rather than confirmed causal mechanisms unless directly measured in the included studies.

Table 1. Research design summary

Component	Description
Review type	Scooping review with structured narrative synthesis.
Reporting framework	PRISMA 2020 reporting guidance was used to structure identification, screening, eligibility, and inclusion procedures (Page et al., 2021).
Main unit of analysis	Published intervention studies on elastic band training in competitive handball players.
Outcome domains	Sprint performance, change of direction/agility, jump performance, upper-limb strength, and/or throwing velocity.
Reason for narrative synthesis	Heterogeneity in populations, intervention protocols, band intensity units, comparator conditions, and outcome measures.
Mechanistic interpretation	Mechanistic explanations were treated as plausible interpretations unless directly measured in the included studies.

Research Subjects

Because this study was a scooping review, the research subjects were published studies and the participants reported within those studies. The target population consisted of controlled intervention studies involving competitive handball players who completed elastic band, resistance band, TheraBand, elastic tubing, or rubber band training. The supplied manuscript reports that 12 studies met the eligibility criteria and were included in the qualitative synthesis, representing approximately 359 handball players. Individual study samples ranged from 12 to 39 participants, and most participants were youth, adolescent, or junior players aged approximately 15 to 18 years. The study characteristics also indicate that five studies involved male players, and seven studies involved female players.

The sampling procedure was not participant recruitment in the conventional primary-research sense. Instead, it was an evidence-selection procedure based on database searching, duplicate removal, title-and-abstract screening, full-text eligibility assessment, and application of predefined inclusion and exclusion criteria. Eligible studies were required to involve competitive male or female handball players at youth, adolescent, junior, or adult level; include an EBT intervention lasting at least five weeks; use routine training, no additional resistance training, or another active/passive comparator; and report at least one sport-specific performance outcome. The five-week threshold was used to distinguish training-induced adaptations from acute or very short-term responses. Studies were excluded when they focused exclusively on rehabilitation, injury treatment, acute exercise effects, non-handball populations, clinical or non-athletic samples, case reports, conference abstracts without full data, or publications without sufficient performance outcome information. Non-English publications were excluded because translation resources were not available, and this restriction was treated as a potential source of language bias rather than as evidence of lower relevance.

Table 2. PICOS eligibility criteria

PICOS component	Eligibility criterion	Rationale
Population	Competitive handball players, including youth, adolescent, junior, and adult athletes.	Increases sport specificity and reduces heterogeneity from mixed-sport samples.
Intervention	Elastic band, resistance band, TheraBand, elastic tubing, or rubber band training lasting at least five weeks.	Focuses on training adaptations rather than acute responses.
Comparator	Routine training, no additional resistance training, or active/passive control conditions.	Allows interpretation of changes in relation to an intervention context.
Outcomes	Sprint performance, change of direction/agility, jump performance, upper-limb strength, and/or throwing velocity.	Reflects key lower- and upper-limb performance demands in handball.
Study design	Randomized controlled trials, non-randomized controlled trials, and quasi-experimental designs.	Allows inclusion of controlled intervention evidence in a limited sport-specific literature base.

Instruments and Research Procedures

The instruments used in this review were documentary and methodological rather than physical tests administered by the authors. They consisted of a database search protocol, a PICOS-based eligibility checklist, a standardized data extraction form, and domain-based synthesis categories. The search protocol used four information sources: Scopus, PubMed, Web of Science, and Google Scholar. Searches covered studies published from January 2016 to December 2025. The search strategy combined handball terms, elastic-resistance terms, and performance-outcome terms. The core Boolean structure was: ("handball") AND ("elastic band" OR "resistance band" OR "theraband" OR "elastic resistance" OR "resistance tubing" OR "rubber band training") AND ("sprint" OR "change of direction" OR "agility" OR "jump" OR "vertical jump" OR "power" OR "upper limb strength" OR "throwing velocity"). The strategy was adapted to the syntax and indexing system of each database.

The review procedure consisted of six sequential stages. First, records were identified from the selected databases and reference lists of included studies were manually checked. Second, all records were exported into reference management software and duplicates were removed. Third, two reviewers independently screened titles and abstracts against the eligibility criteria. Fourth, full-text articles considered eligible or unclear were assessed against the PICOS criteria. Fifth, disagreements were resolved through discussion, and a third reviewer was available when consensus could not be reached. Sixth, data were extracted independently using a standardized form. The extracted variables included author, year, country, sample size, experimental and control group characteristics, age, sex, competitive level, intervention duration, weekly frequency, sets and repetitions, band intensity or elongation, exercise focus, comparator condition, outcome measures, test protocols, and main findings.

Table 3. Database specific search adaptations

Database	Search adaptation	Limits / screening notes
Scopus	TITLE-ABS-KEY terms were used for handball, elastic resistance synonyms, and performance outcomes.	Publication years were limited to 2016-2025; duplicates were removed after export.
PubMed	Terms were searched in title/abstract fields, when possible, with MeSH terms considered when available.	The date range was restricted to January 2016-December 2025; final eligibility was determined during screening.
Web of Science	Topic search was used to capture title, abstract, author keywords, and Keywords Plus.	Records were limited to the defined publication period and exported for duplicate removal.
Google Scholar	Used as a supplementary source with simplified combinations of handball, elastic resistance, and outcome terms.	The supplied method specifies that the first 200 results sorted by relevance should be screened for reproducibility; this screening depth should be verified by the authors before submission.

Table 4. Data extraction framework

Extraction domain	Extracted information
Bibliographic identity	Author(s), publication year, and country when available.
Sample characteristics	Total sample size, experimental and control groups, age, sex, and competitive level.
Intervention characteristics	Duration, weekly frequency, sets, repetitions, band intensity or elongation, exercise focus, and whether EBT replaced or supplemented routine training.
Comparator	Routine training, no additional resistance training, active control, or passive control condition.
Outcome measures	Sprint distance, COD/agility test, jump test, upper-limb strength test, and throwing-velocity assessment.
Main findings	Reported improvement, non-improvement, or domain-specific change as extracted from the included studies.

Data Analysis

Data were analyzed using structured narrative synthesis. This analytical strategy was selected because the included studies differed in sample characteristics, EBT protocols, intervention duration, weekly frequency, band-intensity reporting, comparator conditions, outcome tests, and reporting of statistical results. The synthesis was organized into four performance domains: sprint performance, change of direction/agility, jump performance, and upper-limb strength or throwing velocity. Within each domain, the analysis considered the direction of reported effects, consistency across studies, intervention duration, weekly training frequency, population characteristics, and whether EBT replaced or supplemented routine training.

The analysis emphasized observed performance outcomes rather than unverified physiological or biomechanical mechanisms. For example, if a study reported improved sprint or COD test performance, the finding was treated as an improvement in that test domain, not as direct evidence of enhanced rate of force development, eccentric braking, or neuromuscular coordination unless such mechanisms were measured directly. This distinction was necessary because several mechanistic explanations in the manuscript were inferential and were supported only indirectly by broader resistance-training, variable-resistance, or COD literature. Where numerical data such as p-values, effect sizes, confidence intervals, percentage changes, or pre-post mean differences were available, they should be extracted and presented in the Results tables. Where these data were not available in the supplied manuscript, the analysis avoided assigning magnitude categories or performing statistical pooling.

The synthesis also considered methodological limitations that influence interpretation. These include the absence of prospective protocol registration, exclusion of non-English publications, limited reproducibility of Google Scholar searching if screening depth is not confirmed, lack of reported inter-reviewer agreement statistics, inconsistent band-intensity metrics across studies, relatively small samples, short intervention durations, and predominance of youth or adolescent participants. These limitations restrict generalization to elite adult handball players and prevent firm causal claims about specific mechanisms. Accordingly, the review interpreted EBT as a potentially useful complementary training modality for selected handball performance outcomes rather than as a definitive standalone intervention.

Table 5. Data analysis plan

Analytical element	Application in this review
Synthesis approach	Structured narrative synthesis rather than meta-analysis.
Performance domains	Sprint performance, change of direction/agility, jump performance, and upper-limb strength or throwing velocity.
Effect interpretation	Direction and consistency of reported effects were prioritized because effect sizes and exact statistical values were not consistently available in the supplied manuscript.
Mechanistic claims	Rate of force development, eccentric braking, stretch-shortening cycle function, neuromuscular coordination, and kinetic-chain transfer were treated as plausible interpretations unless directly measured.
Limitations considered	Short-term studies, small samples, youth/adolescent dominance, inconsistent intensity reporting, and possible language bias.

RESULTS

Study Selection

The database search identified 51 records from Scopus, PubMed, Web of Science, and Google Scholar. After duplicate removal, 22 records were removed before screening, leaving 29 records for title and abstract assessment. Three records were removed at the initial screening stage because they did not meet the review focus, and 26 reports were then sought for retrieval. One report was not retrieved because the full text was unavailable. Of the 25 full-text reports assessed for eligibility, 13 were excluded after full-text review, consisting of two non-English publications, seven studies with ineligible populations, and four reports that did not present relevant performance outcomes. Consequently, 12 studies were included in the structured narrative synthesis. This selection pattern indicates that the final evidence base was narrowed mainly through duplicate removal and full-text eligibility decisions, rather than through title-and-abstract screening alone. The corrected PRISMA 2020 flow diagram is presented in Figure 1.

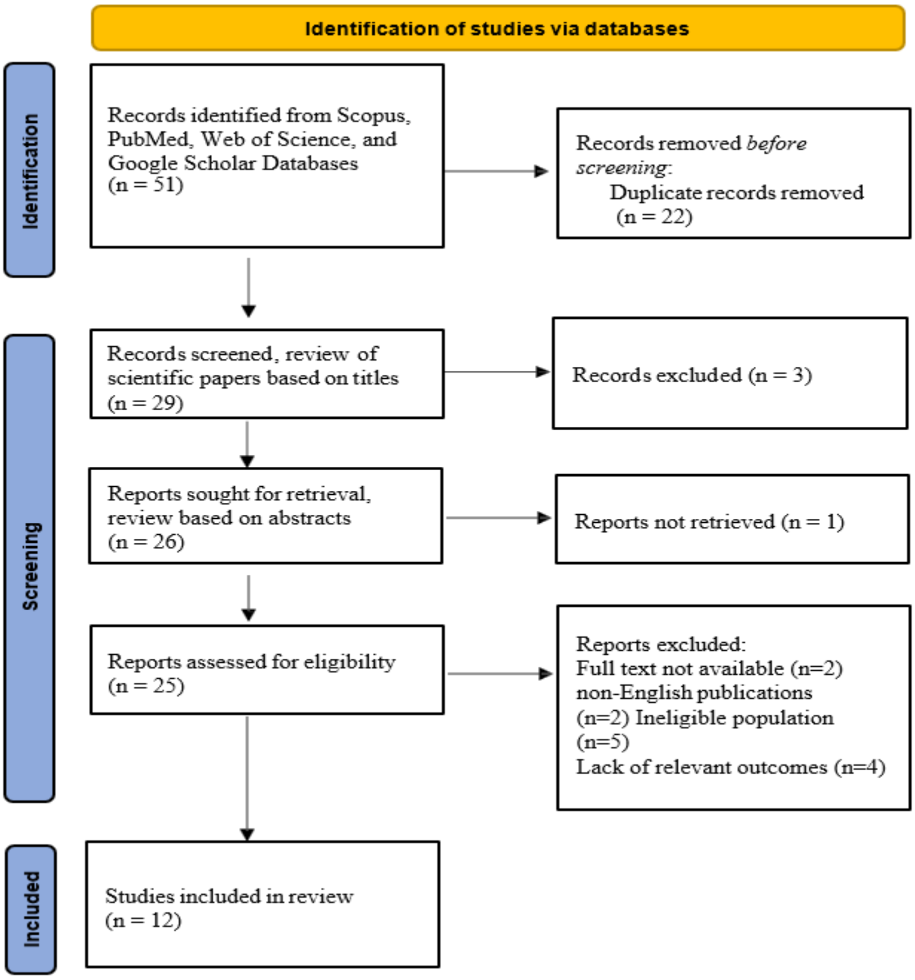

Figure 1. *Corrected PRISMA 2020 study-selection flow diagram.*

Study Characteristics

The 12 included studies involved a total of 359 handball players, with individual sample sizes ranging from 12 to 39 participants. Most participants were youth, adolescent, or junior players, with reported mean ages concentrated around approximately 15 to 18 years. Based on the extracted characteristics, five studies involved male players, and seven studies involved female players. All included studies used an experimental-control structure, although the exact design, allocation procedure, and randomization status differed across studies. The main outcomes assessed across the included studies were sprint performance, change of direction (COD), jump performance, upper-limb strength, shoulder strength, strength endurance, and throwing velocity. The extracted data show that the evidence base was concentrated in short-term interventions involving young handball players rather than adult elite samples. The individual study characteristics and directly reported findings are presented in Table 6, which consolidates the participant profile, intervention duration, outcome domains, and direct result statements for each included study.

Table 6. Characteristics of included studies investigating elastic band training in handball players.

Study	n	Participants	Intervention	Outcomes assessed	Directly reported finding
Mascarin et al. (2017)	39	Youth female; 15.2 +/- 1.0 years	6 weeks; 3 sessions/week	Upper-limb strength; throwing velocity	Reported improvement in shoulder strength and throwing velocity
Andersen et al. (2018)	12	Youth female; 16.5 +/- 0.7 years	9 weeks; 3 sessions/week	Vertical jump; COD	Reported improvement in jump performance, but no significant COD improvement
Aloui et al. (2019a)	30	Junior male; 18.7 +/- 0.8 years	8 weeks; 2 sessions/week	Sprint; COD; jump	Reported improvement in sprint and COD; jump performance was unchanged
Aloui et al. (2019b)	30	Junior male; 18.7 +/- 0.8 years	8 weeks; 2 sessions/week	Upper-limb strength	Reported improvement in upper-limb strength
Aloui et al. (2020)	29	Junior male; 17.9 +/- 0.4 years	8 weeks; 2 sessions/week	Sprint; COD; jump	Reported improvement in sprint and COD; jump performance was unchanged
Aloui et al. (2021)	29	Junior male; 17.9 +/- 0.4 years	8 weeks; 2 sessions/week	Upper-limb strength	Reported improvement in upper-limb strength
Bauer et al. (2021)	32	Adolescent male; 17.0 +/- 0.8 years	9 weeks; 3 sessions/week	Upper-limb strength	Reported improvement in strength endurance and upper-limb strength
Nebigh et al. (2022)	45	Youth female; 14.6 ± 0.3 years	6 weeks; 2 sessions/week	Dinamic balance performance	Reported improvement in balance performance in young male handball players
Hammami et al. (2022a)	28	Youth female; 16.7 +/- 0.2 years	8 weeks; 2 sessions/week	Sprint; COD; jump	Reported improvement in sprint, COD, and jump performance
Hammami et al. (2022b)	26	Youth female; 15.8 +/- 0.2 years	10 weeks; 2 sessions/week	Sprint; COD; jump	Reported improvement in COD and jump performance
Gaamouri et al. (2023)	34	Youth female; 15.8 +/- 0.2 years	10 weeks; 2 sessions/week	COD; jump; sprint	Reported improvement in COD, jump, and sprint performance
Gaamouri et al. (2024)	30	Youth female; 15.8 +/- 0.2 years	10 weeks; 2 sessions/week	Jump; COD; strength	Reported improvement in jump, COD, and strength

Intervention Characteristics

Intervention duration ranged from 6 to 10 weeks, while training frequency ranged from two to three sessions per week. Most studies used elastic resistance as a replacement for part of routine training, whereas one study implemented elastic band work as an additional modality. The extracted intervention data show substantial variation in how elastic band intensity was defined and reported. Some studies used repetition maximum ranges, some reported elongation percentages such as 100%, 200%, or 250%, and others presented kilogram-equivalent estimates or described the load only as elastic resistance. Because these reporting units are not directly interchangeable, the Results do not infer a precise dose-response relationship from band intensity. Instead, the intervention characteristics are presented as originally reported and interpreted descriptively. The overall pattern shows that the studies shared similar short-term training durations and weekly frequencies, but differed in sets, repetitions, loading descriptions, exercise focus, and whether the elastic band intervention targeted lower-limb, upper-limb, or combined upper- and lower-limb actions. These data are summarized in Table 7.

Table 7. Intervention characteristics and intensity-reporting format

Study	Duration and frequency	Sets and repetitions	Band intensity as reported	Exercise focus	Training role
Mascarin et al. (2017)	6 weeks; 3 sessions/week	3 x 10-20 RM	Progressive RM	Shoulder rotation	Addition
Andersen et al. (2018)	9 weeks; 3 sessions/week	3 x 6-10 RM	Elastic resistance	Explosive lower-limb exercises	Replacement
Aloui et al. (2019a)	8 weeks; 2 sessions/week	3 x 12-15	200% elongation	Lower limb	Replacement
Aloui et al. (2019b)	8 weeks; 2 sessions/week	3 x 12-15	250% elongation	Upper limb	Replacement
Aloui et al. (2020)	8 weeks; 2 sessions/week	5 x 6 reps	41-81 kg equivalent	Lower limb plus plyometric training	Replacement
Aloui et al. (2021)	8 weeks; 2 sessions/week	5 x 6 reps	11-26 kg	Upper limb	Replacement
Bauer et al. (2021)	9 weeks; 3 sessions/week	3 x 8-12	100% elongation	Upper limb	Replacement
Hammami et al. (2022a)	10 weeks; 2 sessions/week	3-5 x 12	200% elongation	Lower and upper limb	Replacement
Hammami et al. (2022b)	10 weeks; 2 sessions/week	3-5 x 12	250% elongation	Lower and upper limb	Replacement
Hammami et al. (2022c)	10 weeks; 2 sessions/week	3-5 x 10	250% elongation	Lower and upper limb	Replacement
Gaamouri et al. (2023)	10 weeks; 2 sessions/week	3-5 x 10	250% elongation	Lower and upper limb	Replacement
Gaamouri et al. (2024)	10 weeks; 2 sessions/week	3-5 x 12	3.2-8.8 kg	Lower and upper limb	Replacement

Outcome Synthesis

Sprint outcomes were reported mainly over short distances, particularly 5-10 m, with some studies also assessing 20-30 m sprint performance. Based on the extracted study table, sprint-related improvements were reported in most studies that measured sprint performance, especially in interventions lasting at least 8 weeks. The evidence presented in the source document does not consistently provide exact p-values, confidence intervals, or effect sizes for every sprint outcome, so the synthesis reports only the direction and presence of improvement as documented. Change of direction outcomes were reported using modified T-tests, agility tests, or sport-specific directional-change assessments. Most studies that assessed COD reported improvement after elastic band training, although Andersen et al. (2018) reported no significant COD improvement. Therefore, COD was the most frequently improved outcome domain, but the pattern was not uniformly positive across all studies. The outcome-domain synthesis is presented in Table 4.

Jump performance was assessed through vertical or horizontal jump tests, including squat jump or countermovement jump outcomes in several studies. Most studies reported positive jump-related outcomes, but the pattern was more variable than the COD findings. Aloui et al. (2019; 2019b) and Aloui et al. (2020) reported unchanged jump performance despite reporting improvements in sprint and COD. This indicates that jump adaptations were not consistently present across all elastic band protocols. Upper-limb strength, shoulder strength, strength endurance, and throwing-related outcomes were examined in a smaller group of studies than sprint, COD, and jump outcomes. These studies generally reported improvements after elastic band training, particularly in shoulder-related strength and throwing velocity. However, the extracted data did not consistently separate upper-limb strength from broader strength outcomes in every study. For this reason, the Results report the observed performance outcomes only and avoid attributing the findings to unmeasured biomechanical or physiological mechanisms.

Table 8. Summary of outcome domain findings.

Outcome domain	Measures reported	Observed pattern	Reporting limitation
Sprint performance	Mainly 5-10 m; some 20-30 m tests	Improvements were reported in most studies that measured sprint performance, particularly after interventions lasting at least 8 weeks.	Exact effect sizes, confidence intervals, and p-values were not consistently available in the extracted manuscript.
Change of direction	Modified T-tests, agility tests, or sport-specific COD assessments	Most studies reported improvement; Andersen et al. (2018) reported no significant COD improvement.	COD was frequently improved, but the evidence was not uniformly positive.
Jump performance	Vertical or horizontal jump tests; squat jump or countermovement jump outcomes	Several studies reported improvement, but Aloui et al. (2019a) and Aloui et al. (2020) reported unchanged jump outcomes.	Jump outcomes were more variable than COD outcomes.
Upper-limb strength and throwing-related outcomes	Shoulder strength, upper-limb strength, strength endurance, throwing velocity	Studies assessing these outcomes generally reported improvements after elastic band training.	Outcome reporting did not consistently separate upper-limb strength from general strength outcomes.

DISCUSSION

Overall evidence pattern and meaning of the findings

The overall evidence pattern indicates that elastic band training (EBT) is best interpreted as a complementary, task-oriented conditioning method rather than as a universal substitute for comprehensive handball preparation. The significance of this finding is that the observed benefits across acceleration, change of direction (COD), selected jump outcomes, and upper-limb or throwing-related performance reflect the multidimensional nature of handball performance, where repeated explosive actions must be produced under spatial and technical constraints. Theoretically, the finding is consistent with training-specificity and progressive-overload principles, elastic resistance can alter the force demand across a movement range, but the transfer to field performance depends on whether the exercises reproduce the direction, timing, and coordination demands of the target task (Colado et al., 2020; Wilson & Kritz, 2014). The pattern is supported by handball-specific EBT studies showing improvements in lower-limb or upper-limb performance domains (Aloui et al., 2021; Andersson et al., 2018a; Hammami, Gaamouri, Cherni, et al., 2022; Mascarin et al., 2017). However, studies outside the included EBT set show that physical performance in handball is also influenced by functional movement quality, body asymmetry, load exposure, and position-specific demands (Atalay et al., 2018; Font et al., 2021; Lijewski et al., 2021; Rafnsson et al., 2019). The similarity lies in the recognition that handball performance is not determined by one isolated capacity; the difference lies in the fact that these broader studies did not isolate elastic resistance as the training stimulus. This difference may be explained by variation in study purpose, testing batteries, competitive level, and whether the studies examined training effects or descriptive performance characteristics. The limitation of the present synthesis is that it relies mainly on short-term controlled studies with heterogeneous protocols and incomplete reporting of effect sizes and risk-of-bias judgments. The implication is that EBT should be placed within an integrated performance model that combines resistance training, technical practice, workload monitoring, and athlete-specific screening rather than being interpreted as a single-mechanism intervention.

Sprint performance

The sprint-related findings suggest that EBT has its strongest practical meaning for acceleration over short distances, not necessarily for maximal velocity development. This distinction matters because handball sprinting usually occurs in confined spaces, where the first steps, rapid repositioning, and repeated accelerations are more decisive than long straight-line running. From a theoretical perspective, acceleration improvement is linked to the ability to apply force rapidly and effectively in a task-specific direction, while resistance training adaptations depend on the interaction between load, movement velocity, and technical execution (Suchomel et al., 2018, 2021). The included lower-limb EBT studies that reported sprint improvements are consistent with this interpretation because their protocols targeted explosive lower-limb actions and short-term neuromuscular adaptations (Aloui, Hermassi, et al., 2019a; Aloui et al., 2020; Hammami, Gaamouri, Cherni, et al., 2022; Hammami, Gaamouri, Wagner, et al., 2022). Related handball research also supports the importance of power and field-based performance testing, modified strength programmes during the competitive period have been linked with power development, and on-court testing has been used to capture performance differences among high-level players (Spieszny & Zubik, 2018; Wagner et al., 2020). At the same time, not all studies that assess handball performance use the same sprint distances or physiological indicators. For example, intermittent running fitness tests and kinanthropometric-performance studies focus more on repeated or general physical capacity than on isolated acceleration mechanics (Mohoric et al., 2022; Romero-García et al., 2022). The difference between these studies and the present synthesis lies in the outcome level: the EBT evidence concerns short sprint test changes, whereas broader handball studies examine the physical profile that may support match demands. Scientifically, variation in sprint findings may result from differences in training duration, baseline strength, maturation, band tension, and whether the exercises emphasized horizontal projection. A key limitation is the absence of consistent force-velocity profiling, split-time reporting, or mechanical analysis. Practically, coaches should use EBT to support acceleration qualities, but it should be combined with sprint technique, resisted sprint drills, and sport-specific running patterns.

*Change **of direction performance***

COD performance represents the clearest and most practically meaningful pattern in the synthesis because the movement demands of handball require players to decelerate, redirect force, and reaccelerate repeatedly during offensive and defensive sequences. The theoretical relevance of this finding lies in the fact that COD is not simply a speed outcome; it also reflects braking capacity, trunk control, lower-limb alignment, asymmetry management, and the ability to orient force in the intended direction (Chaabene et al., 2022; Dos'Santos et al., 2018, 2019). The EBT studies reporting COD improvements are therefore plausible because elastic resistance can be organized into lateral, diagonal, or multidirectional drills that load the athlete through directions like cutting and reacceleration actions (Aloui et al., 2020; Aloui et al., 2019a; Hammami et al., 2022a; 2022b). Supporting handball literature shows that COD is related to other neuromuscular capacities, including jumping ability, balance, dynamic postural control, and sport-specific coordination (Katsumata & Aoki, 2021; Mohamad Puzi & Choo, 2021; Picot et al., 2022). The main divergent result in the included evidence is that Andersen et al. (2018) found improved jump performance without significant COD improvement, suggesting that general explosive resistance work does not always transfer to directional-change tasks. The specific difference is that jump tests mainly emphasize vertical or horizontal propulsion, whereas COD tests additionally require braking, foot placement, body reorientation, and rapid transition from deceleration to acceleration. This difference may be caused by exercise selection, test selection, and whether the intervention included lateral or cutting-specific elastic resistance movements. The limitation is that most included studies used field tests rather than force plates, braking impulse measures, or kinematic analyses. The practical implication is that EBT for COD should not consist only of general band-resisted strength drills; it should include progressive cutting, stopping, lateral movement, and reacceleration patterns that mirror handball play.

Jump performance

The jump-performance findings require a more cautious interpretation because positive effects were present in several studies, but the pattern was less consistent than COD. The meaning of this result is that EBT may contribute to lower-limb explosiveness when the training stimulus is compatible with jump mechanics, but elastic resistance does not guarantee improvement in every jump test. Theoretically, jumping requires coordinated stretch-shortening cycle function, rapid concentric force production, stiffness regulation, and effective transfer from preparatory lowering to take-off. These demands overlap with strength and power concepts but remain mechanically distinct from sprint acceleration and COD (Suchomel et al., 2018, 2021). The studies reporting favorable jump outcomes are consistent with interventions that included explosive or combined lower-limb actions(Andersen et al., 2018; Hammami, et al., 2022a; 2022b). Handball-related studies also suggest that jumping is associated with COD performance and that muscle power can be influenced by sport-specific or acute performance factors (Kaczka et al., 2022; Katsumata & Aoki, 2021; Rocha et al., 2021). In contrast, Aloui et al. (2020; 2019a) reported unchanged jump performance despite sprint and COD improvements. The specific difference is that sprint and COD adaptations may reflect acceleration and braking ability, while jump tests require sufficient vertical or horizontal impulse and take-off mechanics. This divergence may be explained by band orientation, external load magnitude, repetition structure, baseline training status, and whether the protocol sufficiently loaded the stretch-shortening cycle. Supporting evidence from strength modification in handball suggests that power adaptations are sensitive to programme structure during the competitive period (Spieszny & Zubik, 2018). A limitation of the present review is that the Results did not consistently provide p-values, effect sizes, jump-test protocols, or mechanical variables such as take-off velocity and impulse. The implication is that EBT can be useful for jump development only when it is paired with jump-specific plyometric tasks and monitored through clearly defined vertical and horizontal jump measures.

Upper-limb strength and throwing-related performance

The upper-limb and throwing-related findings are especially relevant because handball performance depends on high-velocity overhead throwing, repeated shoulder actions, and coordinated force transfer across the lower limbs, trunk, shoulder, and arm. The significance of the positive pattern is that elastic resistance may provide a practical stimulus for shoulder rotation, scapular control, and upper-limb force production, particularly in youth or junior players who need progressive and accessible loading. Theoretically, throwing performance requires both local shoulder capacity and whole-chain coordination; therefore, isolated band exercises may improve some strength components but may not fully explain changes in ball velocity unless they are integrated with technical and trunk-based training. The included findings from Mascarin et al. (2017) and Aloui et al. (2021; 2019a) are supported by other handball studies showing the relevance of shoulder strength, throwing velocity, and resistance-band training to upper-limb performance (Hermassi et al., 2021; Kusumawati et al., 2022). However, a different interpretation is suggested by Fredriksen et al., (2021) who found no added benefit of a short external-rotation elastic-band programme over usual handball training alone in youth players. The difference is specific: the favorable studies often examined broader upper-limb strength or throwing-related performance, whereas the divergent trial focused on additional external rotation strength work and shoulder strength ratios. This discrepancy may be caused by different outcomes, training volume, integration with regular practice, baseline shoulder status, and whether the exercises targeted isolated rotator-cuff strength or throwing-specific power. Injury and shoulder-function studies further show that shoulder adaptation in handball is complex, involving pain, range of motion, posterior stiffness, rotation strength, and overuse risk (Albarova-Corral et al., 2022; Andersson et al., 2017, 2018a; Liaghat et al., 2020; Seabra et al., 2017; Vigolvino et al., 2020). The limitation is that most included studies did not measure electromyography, three-dimensional kinematics, or trunk-shoulder sequencing. Practically, EBT should be used as part of shoulder conditioning and throwing preparation, not as a replacement for technical throwing practice or comprehensive injury-prevention programmes.

Intervention dose, evidence boundaries, and practical implications

The dose-related findings indicate that the reviewed EBT programmes were generally short term and implemented two to three times per week, but the more important interpretation is that dosage cannot yet be standardized because band intensity was reported through non-equivalent metrics such as repetition maximum, percentage elongation, kilogram-equivalent load, and general elastic-resistance descriptions. Theoretically, this limits causal interpretation because resistance-training adaptation depends on progression, load quantification, fatigue management, movement specificity, and athlete readiness (Suchomel et al., 2021). The included EBT studies collectively suggest practical usefulness, but the broader handball literature shows why dosage must be individualized: injuries and training responses vary by age, position, load exposure, pain status, postural control, and youth-development context (Aasheim et al., 2018; Achenbach et al., 2018; Ageberg et al., 2022; Mashimo et al., 2021; Picot et al., 2022). Studies of external load monitoring and injury-prevention implementation further indicate that conditioning programmes are more effective when they are embedded in realistic training environments rather than treated as isolated laboratory interventions (Ageberg et al., 2022; Font et al., 2021). The difference between the present synthesis and these broader studies is that the present review focuses on performance outcomes after EBT, whereas the wider literature often examines injury risk, monitoring, or implementation. This difference may be explained by study design, as controlled interventions prioritize outcome change while cohort and implementation studies prioritize ecological validity. Methodologically, the review is limited by small samples, short intervention duration, incomplete risk-of-bias and certainty assessment, and inconsistent reporting of statistical estimates. These limitations do not negate the performance pattern, but they restrict the strength of recommendation. The practical implication is that EBT should be prescribed with explicit reporting of band type, elongation, exercise tempo, volume, progression, and integration with regular handball training. Future research should combine field tests with biomechanical and neuromuscular measures to determine whether the observed performance changes are causal, dose-dependent, and generalizable beyond youth and adolescent handball players.

CONCLUSION

This scooping review concludes that elastic band training may be a useful complementary strategy for improving selected sport-specific performance outcomes in handball players, particularly short-distance acceleration, change of direction ability, selected jump outcomes, and upper-limb or throwing-related performance. The evidence most consistently supports its relevance for directional-change performance, while the effects on jumping appear more dependent on protocol design and exercise specificity. Thus, the review answers its objective by showing that elastic band training is associated with favorable performance changes in several handball-relevant domains, but the strength of this conclusion remains conditional rather than definitive. The main scientific contribution is the clarification that the value of elastic band training in handball should be understood primarily from observed performance outcomes, not from confirmed physiological or biomechanical mechanisms. Explanations involving rate of force development, eccentric braking, stretch-shortening cycle efficiency, neuromuscular coordination, and kinetic-chain transfer remain plausible but insufficiently verified because most included studies did not directly measure these mechanisms. Practically, elastic band training can be integrated into strength and conditioning programs for youth and adolescent handball players as a portable and adaptable modality, particularly when combined with conventional strength, sprint, plyometric, technical, and throwing practice rather than used as a standalone intervention. This review is limited by the predominance of small, short-term studies, heterogeneous band-intensity reporting, inconsistent availability of statistical estimates, and the absence of completed risk-of-bias and certainty-of-evidence assessments. Future research should use larger randomized controlled trials, standardized reporting of elastic resistance dosage, longer follow-up periods, and direct biomechanical or neuromuscular measurements to determine the mechanisms, optimal loading strategies, and generalizability of elastic band training effects to elite adult handball players.

REFERENCES

Aasheim, C., Stavenes, H., Andersson, S. H., Engbretsen, L., & Clarsen, B. (2018). Prevalence and burden of overuse injuries in elite junior handball. *BMJ Open Sport and Exercise Medicine*, *4*(1). Scopus. https://doi.org/10.1136/bmjsem-2018-000391

Achenbach, L., Loose, O., Laver, L., Zeman, F., Nerlich, M., Angele, P., & Krutsch, W. (2018). Beach handball is safer than indoor team handball: Injury rates during the 2017 European Beach Handball Championships. *Knee Surgery, Sports Traumatology, Arthroscopy*, *26*(7), 1909–1915. Scopus. https://doi.org/10.1007/s00167-018-4907-5

Ageberg, E., Brodin, E. M., Linnéll, J., Moesch, K., Donaldson, A., Adébo, E., Benjaminse, A., Ekengren, J., Granér, S., Johnson, U., Lucander, K., Myklebust, G., Møller, M., Tranaeus, U., & Bunke, S. (2022). Cocreating injury prevention training for youth team handball: Bridging theory and practice. *BMJ Open Sport and Exercise Medicine*, *8*(2). Scopus. https://doi.org/10.1136/bmjsem-2021-001263

Albarova-Corral, M. I., Cardiel-Sánchez, S., Fanlo-Mazas, P., Ruiz-De-Escudero-Zapico, A., Viorreta-Pintanel, P., & Malo-Urriés, M. (2022). A comparative study on shoulder pain, function, range of motion, and structure between handball players and non-throwing subjects. *Gazzetta Medica Italiana Archivio per Le Scienze Mediche*, *181*(10), 724–730. Scopus. https://doi.org/10.23736/S0393-3660.21.04710-0

Aloui, G., Hammami, M., Fathloun, M., Hermassi, S., Gaamouri, N., Shephard, R. J., & Chelly, M. S. (2019a). Effects of an 8-Week In-Season Elastic Band Training Program on Explosive Muscle Performance, Change of Direction, and Repeated Changes of Direction in the Lower Limbs of Junior Male Handball Players. *Journal of Strength and Conditioning Research*, *33*(7), 1804–1815. https://doi.org/10.1519/JSC.0000000000002786

Aloui, G., Hermassi, S., Hammami, M., Cherni, Y., Gaamouri, N., Shephard, R. J., van den Tillaar, R., & Chelly, M. S. (2020). Effects of Elastic Band Based Plyometric Exercise on Explosive Muscular Performance and Change of Direction Abilities of Male Team Handball Players. *Frontiers in Physiology*, *11*. Scopus. https://doi.org/10.3389/fphys.2020.604983

Aloui, G., Hermassi, S., Hammami, M., Gaamouri, N., Bouhafs, E. G., Comfort, P., Shephard, R. J., Schwesig, R., & Chelly, M. S. (2019b). Effects of an 8-Week In-Season Upper Limb Elastic Band Training Programme on the Peak Power, Strength, and Throwing Velocity of Junior Handball Players. *Sportverletzung-Sportschaden*, *33*(3), 133–141. Scopus. https://doi.org/10.1055/a-0819-5185

Aloui, G., Hermassi, S., Hayes, L. D., Shephard, R. J., Chelly, M. S., & Schwesig, R. (2021). Effects of elastic band plyometric training on physical performance of team handball players. *Applied Sciences (Switzerland)*, *11*(3), 1–13. Scopus. https://doi.org/10.3390/app11031309

Andersen, V., Fimland, M., Cumming, K., Vraalsen, Ø., & Saeterbakken, A. (2018). Explosive Resistance Training Using Elastic Bands in Young Female Team Handball Players. *Sports Medicine International Open*, *02*(06), E171–E178. https://doi.org/10.1055/a-0755-7398

Andersson, S. H., Bahr, R., Clarsen, B., & Myklebust, G. (2017). Preventing overuse shoulder injuries among throwing athletes: A cluster-randomised controlled trial in 660 elite handball players. *British Journal of Sports Medicine*, *51*(14), 1073–1080. Scopus. https://doi.org/10.1136/bjsports-2016-096226

Andersson, S. H., Bahr, R., Clarsen, B., & Myklebust, G. (2018). Risk factors for overuse shoulder injuries in a mixed-sex cohort of 329 elite handball players: Previous findings could not be confirmed. *British Journal of Sports Medicine*, *52*(18), 1191–1198. Scopus. https://doi.org/10.1136/bjsports-2017-097648

Atalay, E. S., Tarakci, D., & Algun, C. (2018). Are the functional movement analysis scores of handball players related to athletic parameters? *Journal of Exercise Rehabilitation*, *14*(6), 954–959. Scopus. https://doi.org/10.12965/jer.1836372.186

Bauer, J., Schwiertz, G., & Muehlbauer, T. (2021). Diverging Playing Positions do not Lead to Differences in YBT-UQ Performance in Youth Handball Players. *Sports Medicine International Open*, *05*(03), E99–E103. https://doi.org/10.1055/a-1647-7174

Chaabene, H., Markov, A., Prieske, O., Moran, J., Behrens, M., Negra, Y., Ramirez-Campillo, R., Koch, U., & Mkaouer, B. (2022). Effect of Flywheel versus Traditional Resistance Training on Change of Direction Performance in Male Athletes: A Systematic Review with Meta-Analysis. *International Journal of Environmental Research and Public Health*, *19*(12), 7061. https://doi.org/10.3390/ijerph19127061

Chelly, M. S., Hermassi, S., Aouadi, R., & Shephard, R. J. (2014). Effects of 8-Week In-season Plyometric Training on Upper and Lower Limb Performance of Elite Adolescent Handball Players. *Journal of Strength and Conditioning Research*, *28*(5), 1401–1410. https://doi.org/10.1519/JSC.0000000000000279

Colado, J. C., Mena, R., Calatayud, J., Gargallo, P., Flández, J., & Page, P. (2020). Effects of strength training with variable elastic resistance across the lifespan: A systematic review. *Cultura, Ciencia y Deporte*, *15*(44), 147–164. https://doi.org/10.12800/ccd.v15i44.1458

Dos'Santos, T., Thomas, C., Comfort, P., & Jones, P. A. (2018). Comparison of Change of Direction Speed Performance and Asymmetries between Team-Sport Athletes: Application of Change of Direction Deficit. *Sports*, *6*(4), 174. https://doi.org/10.3390/sports6040174

Dos'Santos, T., Thomas, C., Jones, P. A., & Comfort, P. (2019). Assessing Asymmetries in Change of Direction Speed Performance: Application of Change of Direction Deficit. *Journal of Strength and Conditioning Research*, *33*(11), 2953–2961. https://doi.org/10.1519/JSC.0000000000002438

Font, R., Karcher, C., Reche, X., Carmona, G., Tremps, V., & Irurtia, A. (2021). Monitoring external load in elite male handball players depending on playing positions. *Biology of Sport*, *38*(3), 475–481. Scopus. https://doi.org/10.5114/BIOLSPORT.2021.101123

Fredriksen, H., Cools, A., & Myklebust, G. (2021). No added benefit of 8 weeks of shoulder external rotation strength training for youth handball players over usual handball training alone: A randomized controlled trial. *Journal of Orthopaedic and Sports Physical Therapy*, *51*(4), 174–187. Scopus. https://doi.org/10.2519/JOSPT.2021.9957

Gaamouri, N., Hammami, M., Cherni, Y., Oranchuk, D. J., Bragazzi, N., Knechtle, B., Chelly, M. S., & Van Den Tillaar, R. (2023). The effects of upper and lower limb elastic band training on the change of direction, jump, power, strength and repeated sprint ability performance in adolescent female handball players. *Frontiers in Sports and Active Living*, *5*, 1021757. https://doi.org/10.3389/fspor.2023.1021757

Gaamouri, N., Hammami, M., Cherni, Y., Oranchuk, D., Van Den Tillaar, R., & Chelly, M. S. (2024). Rubber Band Training Improves Athletic Performance in Young Female Handball Players. *Journal of Human Kinetics*, *92*, 227–238. https://doi.org/10.5114/jhk/175396

Hammami, M., Gaamouri, N., Cherni, Y., Gaied, S., Chelly, M. S., Hill, L., Nikolaidis, P. T., & Knechtle, B. (2022). Effects of complex strength training with elastic band program on repeated change of direction in young female handball players: Randomized control trial. *International Journal of Sports Science & Coaching*, *17*(6), 1396–1407. https://doi.org/10.1177/17479541211062152

Hammami, M., Gaamouri, N., Wagner, H., C Pagaduan, J., Hill, L., T Nikolaidis, P., Knechtle, B., & Souhaiel Chelly, M. (2022). Effects of strength training with elastic band programme on fitness components in young female handball players: A randomized controlled trial. *Biology of Sport*, *39*(3), 537–545. https://doi.org/10.5114/biolsport.2022.106390

Hermassi, S., Chelly, M. S., Tabka, Z., Shephard, R. J., & Chamari, K. (2011). Effects of 8-Week in-Season Upper and Lower Limb Heavy Resistance Training on The Peak Power, Throwing Velocity, and Sprint Performance of Elite Male Handball Players. *Journal of Strength and Conditioning Research*, *25*(9), 2424–2433. https://doi.org/10.1519/JSC.0b013e3182030edb

Hermassi, S., Hayes, L. D., & Schwesig, R. (2021). Can body fat percentage, body mass index, and specific field tests explain throwing ball velocity in team handball players? *Applied Sciences (Switzerland)*, *11*(8). Scopus. https://doi.org/10.3390/app11083492

Kaczka, P., Maciejczyk, M., Batra, A., Tabęcka-łonczyńska, A., & Strzała, M. (2022). Acute Effect of Caffeine-Based Multi-Ingredient Supplement on Reactive Agility and Jump Height in Recreational Handball Players. *Nutrients*, *14*(8). Scopus. https://doi.org/10.3390/nu14081569

Karcher, C., & Buchheit, M. (2014). On-Court Demands of Elite Handball, with Special Reference to Playing Positions. *Sports Medicine*, *44*(6), 797–814. https://doi.org/10.1007/s40279-014-0164-z

Katsumata, K., & Aoki, K. (2021). Jumping ability is related to change of direction ability in elite handball players. *Journal of Electromyography and Kinesiology*, *60*. Scopus. https://doi.org/10.1016/j.jelekin.2021.102575

Kusumawati, M., Hidayat, I. I., Haqiyah, A., & Subarno, L. (2022). The effects of forearm resistance band training on the throwing velocity of male handball players. *Journal of Physical Education and Sport*, *22*(11), 2879–2885. Scopus. https://doi.org/10.7752/jpes.2022.11364

Liaghat, B., Bencke, J., Zebis, M. K., Sørensen, H., Myklebust, G., Wedderkopp, N., Lind, M., & Møller, M. (2020). Shoulder rotation strength changes from preseason to midseason: A cohort study of 292 youth elite handball players without shoulder problems. *Journal of Orthopaedic and Sports Physical Therapy*, *50*(7), 381–387. Scopus. https://doi.org/10.2519/jospt.2020.9183

Lijewski, M., Burdukiewicz, A., Pietraszewska, J., Andrzejewska, J., & Stachoń, A. (2021). Asymmetry of muscle mass distribution and grip strength in professional handball players. *International Journal of Environmental Research and Public Health*, *18*(4), 1–12. Scopus. https://doi.org/10.3390/ijerph18041913

Lopes, J. S. S., Machado, A. F., Micheletti, J. K., De Almeida, A. C., Cavina, A. P., & Pastre, C. M. (2019). Effects of training with elastic resistance versus conventional resistance on muscular strength: A systematic review and meta-analysis. *SAGE Open Medicine*, *7*, 2050312119831116. https://doi.org/10.1177/2050312119831116

Mascarin, N. C., de Lira, C. A. B., Vancini, R. L., da Silva, A. C., & Andrade, M. S. (2017). The effects of preventive rubber band training on shoulder joint imbalance and throwing performance in handball players: A randomized and prospective study. *Journal of Bodywork and Movement Therapies*, *21*(4), 1017–1023. Scopus. https://doi.org/10.1016/j.jbmt.2017.01.003

Mashimo, S., Yoshida, N., Takegami, A., Suzuki, K., & Onishi, S. (2021). Injury pattern according to player position in Japanese youth handball: A cross-sectional study among 2377 players. *Physical Therapy in Sport*, *50*, 7–14. Scopus. https://doi.org/10.1016/j.ptsp.2021.03.016

Michalsik, L., Aagaard, P., & Madsen, K. (2012). Locomotion Characteristics and Match-Induced Impairments in Physical Performance in Male Elite Team Handball Players. *International Journal of Sports Medicine*, *34*(07), 590–599. https://doi.org/10.1055/s-0032-1329989

Mohamad Puzi, M. H. B., & Choo, L. A. (2021). The effect of six weeks cobagi training on coordination, dynamic balance & agility of adolescent handball players. *Pedagogy of Physical Culture and Sports*, *25*(1), 31–38. Scopus. https://doi.org/10.15561/26649837.2021.0105

Mohoric, U., Sibila, M., Abazovic, E., Jovanovic, S., & Paravlic, A. H. (2022). Comparison of the Field-Based Intermittent Running Fitness Test 30-15 and the Treadmill Multistage Incremental Test for the Assessment of Cardiorespiratory Fitness in Elite Handball Players. *International Journal of Environmental Research and Public Health*, *19*(6). Scopus. https://doi.org/10.3390/ijerph19063535

Nebigh, A., Hammami, R., Kasmi, S., Rebai, H., Drury, B., Chtara, M., & Van Den Tillaar, R. (2022). The Influence of Maturity Status on Dynamic Balance Following 6 Weeks of Eccentric Hamstring Training in Youth Male Handball Players. *International Journal of Environmental Research and Public Health*, *19*(15), 9775. https://doi.org/10.3390/ijerph19159775

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. https://doi.org/10.1136/bmj.n71

Picot, B., Dury, J., Néron, G., McKeon, P. O., & Forestier, N. (2022). Establishing Normative Dynamic Postural Control Values in Elite Female Handball Players. *International Journal of Sports Physical Therapy*, *17*(6), 1083–1094. Scopus. https://doi.org/10.26603/001c.38174

Póvoas, S. C. A., Seabra, A. F. T., Ascensão, A. A. M. R., Magalhães, J., Soares, J. M. C., & Rebelo, A. N. C. (2012). Physical and Physiological Demands of Elite Team Handball. *Journal of*

Strength and Conditioning Research, *26*(12), 3365–3375. https://doi.org/10.1519/JSC.0b013e318248aeee

Rafnsson, E. T., Myklebust, G., Bahr, R., Valdimarsson, Ö., Frohm, A., & Árnason, Á. (2019). Characteristics of functional movement screening testing in elite handball players: Indicative data from the 9+. *Physical Therapy in Sport*, *37*, 15–20. Scopus. https://doi.org/10.1016/j.ptsp.2019.02.001

Rocha, J. C. C., da Rocha, A. L. S., da Silva Santos Soares, G., & Correia-Oliveira, C. R. (2021). Effects of caffeine ingestion on upper and lower limb muscle power of handball players: A double-blind, placebo-controlled, crossover study. *Sport Sciences for Health*, *17*(4), 1039–1044. Scopus. https://doi.org/10.1007/s11332-021-00803-1

Romero-García, D., Esparza-Ros, F., García, M. P., Martínez-Sanz, J. M., & Vaquero-Cristóbal, R. (2022). Adherence to the Mediterranean diet, kinanthropometric characteristics and physical performance of young male handball players. *PeerJ*, *10*. Scopus. https://doi.org/10.7717/peerj.14329

Seabra, P., Van Eck, C. F., Sá, M., & Torres, J. (2017). Are professional handball players at risk for developing a glenohumeral internal rotation deficit in their dominant arm? *Physician and Sportsmedicine*, *45*(2), 77–81. Scopus. https://doi.org/10.1080/00913847.2017.1295774

Spieszny, M., & Zubik, M. (2018). Modification of Strength Training Programs in Handball Players and its Influence on Power during the Competitive Period. *Journal of Human Kinetics*, *63*(1), 149–160. Scopus. https://doi.org/10.2478/hukin-2018-0015

Suchomel, T. J., Nimphius, S., Bellon, C. R., Hornsby, W. G., & Stone, M. H. (2021). Training for Muscular Strength: Methods for Monitoring and Adjusting Training Intensity. *Sports Medicine*, *51*(10), 2051–2066. https://doi.org/10.1007/s40279-021-01488-9

Suchomel, T. J., Nimphius, S., Bellon, C. R., & Stone, M. H. (2018). The Importance of Muscular Strength: Training Considerations. *Sports Medicine*, *48*(4), 765–785. https://doi.org/10.1007/s40279-018-0862-z

Suchomel, T. J., Nimphius, S., & Stone, M. H. (2016). The Importance of Muscular Strength in Athletic Performance. *Sports Medicine*, *46*(10), 1419–1449. https://doi.org/10.1007/s40279-016-0486-0

Vigolvino, L. P., Barros, B. R. S., Medeiros, C. E. B., Pinheiro, S. M., & Sousa, C. O. (2020). Analysis of the presence and influence of Glenohumeral Internal Rotation Deficit on posterior stiffness and isometric shoulder rotators strength ratio in recreational and amateur handball players. *Physical Therapy in Sport*, *42*, 1–8. Scopus. https://doi.org/10.1016/j.ptsp.2019.12.004

Wagner, H., Fuchs, P., & Michalsik, L. B. (2020). On-court game-based testing in world-class, top-elite, and elite adult female team handball players. *Translational Sports Medicine*, *3*(3), 263–270. Scopus. https://doi.org/10.1002/tsm2.139

Wagner, H., Pfusterschmied, J., Tilp, M., Landlinger, J., Von Duvillard, S. P., & Müller, E. (2014). Upper-body kinematics in team-handball throw, tennis serve, and volleyball spike. *Scandinavian Journal of Medicine & Science in Sports*, *24*(2), 345–354. https://doi.org/10.1111/j.1600-0838.2012.01503.x

Wilson, J., & Kritz, M. (2014). Practical Guidelines and Considerations for the Use of Elastic Bands in Strength and Conditioning. *Strength & Conditioning Journal*, *36*(5), 1–9. https://doi.org/10.1519/SSC.0000000000000087