# DIFFERENTIAL DIAGNOSIS OF GRIP STRENGTH DEVELOPMENT IN INDIVIDUALS WITH OCCUPATIONAL AND PATHOLOGICAL HYPERMOBILITY: A PILOT STUDY

# ДИФЕРЕНЦІЙНА ДІАГНОСТИКА РОЗВИТКУ СИЛИ ХВАТА В ОСІБ З ПРОФЕСІЙНОЮ ТА ПАТОЛОГІЧНОЮ ГІПЕРМОБІЛЬНІСТЮ: ПІЛОТНЕ ДОСЛІДЖЕННЯ

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**Abstracts**

Grip strength is a fundamental measure of muscle function and rehabilitation potential. Hypermobility syndromes, including Joint Hypermobility Syndrome (JHS) and Hypermobile Ehlers-Danlos Syndrome (hEDS), are associated with joint instability and impaired neuromuscular coordination, potentially affecting strength development.

The purpose of the study is to assess the impact of hypermobility on grip strength development in professional circus performers and office workers over a six-month training period.

**Materials and methods**. The study included 40 participants divided into four groups: circus performers with hypermobility (Group A) and without hypermobility (Group B), as well as office workers with hypermobility (Group C) and a control group without hypermobility (Group D). Grip strength was measured monthly using a hand dynamometer. Statistical analysis included ANOVA, paired t-tests, and correlation analysis ($p < 0.05$).

**Results.** Initial analysis showed that circus performers had higher baseline grip strength than office workers, while hypermobility was associated with lower strength levels regardless of occupational profile. The greatest improvement was observed in circus performers without hypermobility (+20–25%), while the lowest improvement was recorded in office workers with hypermobility (+5–8%). ANOVA confirmed significant differences between groups ($p < 0.001$), and correlation analysis ($r = 0.85$) indicated that participants with higher baseline grip strength achieved greater improvements.

**Conclusions.** The obtained data indicate a significant impact of hypermobility on baseline grip strength and its development during training. Specifically, hypermobility serves as a limiting factor for muscular adaptation, particularly in inactive individuals. Occupational activity plays a crucial role in shaping muscular endurance, as evidenced by the higher rate of grip strength development among circus performers.

Thus, the results of this study highlight the need for personalized training programs for individuals with hypermobility, considering their physiological characteristics. Adapted training methods may contribute to enhancing joint stability, improving muscular coordination, and optimizing physical performance in this population.

***Key words:*** grip strength, hypermobility, performance rehabilitation, rehabilitation, training program, dynamometry, differential diagnosis, physical therapy, muscle adaptation.

Сила хвату є важливим показником м’язової функції, фізичної працездатності та потенціалу реабілітації. Синдроми гіпермобільності, як-от синдром гіпермобільності суглобів (JHS) і гіпермобільний синдром Елерса – Данлоса (hEDS), пов’язані з нестабільністю суглобів та порушеною нейром’язовою координацією, що може впливати на розвиток сили.

**Мета** цього дослідження – оцінити вплив гіпермобільності на розвиток сили хвату в професійних циркових артистів та офісних працівників протягом шестимісячного курсу тренувань.

**Матеріали та методи.** У дослідженні взяли участь 40 осіб, які були розподілені на чотири групи: циркові артисти з гіпермобільністю (група A) та без неї (група B), а також офісні працівники з гіпермобільністю (група C) та без неї (контрольна група D). Сила хвату вимірювалася щомісяця за допомогою ручного динамометра. Статистичний аналіз передбачав дисперсійний аналіз (ANOVA), t-критерій для парних порівнянь і кореляційний аналіз ($p < 0{,}05$).

**Результати.** Початковий аналіз показав, що циркові артисти мали вищі базові показники сили хвата порівняно з офісними працівниками, тоді як гіпермобільність була пов’язана зі зниженими рівнями сили, незалежно від професійного профілю. Найбільше покращення спостерігалося у циркових артистів без гіпермобільності (+20–25 %), тоді як найменше – в офісних працівників з гіпермобільністю (+5–8 %). ANOVA підтвердив значущі відмінності між групами ($p < 0{,}001$), а кореляційний аналіз ($r = 0{,}85$) показав, що учасники з вищими початковими показниками демонстрували кращі результати.

**Висновки.** Отримані дані свідчать про значний вплив гіпермобільності на початковий рівень сили хвату та її розвиток під час тренувань. Зокрема, гіпермобільність є фактором, що обмежує м’язову адаптацію, особливо в неактивних осіб. Професійна діяльність відіграє ключову роль у формуванні м’язової витривалості, що підтверджується високими темпами розвитку сили у циркових артистів.

Таким чином, результати цього дослідження вказують на необхідність розробки персоналізованих тренувальних програм для осіб з гіпермобільністю з урахуванням їхніх фізіологічних особливостей. Адаптовані методики тренування можуть сприяти підвищенню стабільності суглобів, покращенню м’язової координації та оптимізації фізичної працездатності у цієї категорії осіб.

***Ключові слова:*** сила хвату, гіпермобільність, виконавські види мистецтва, реабілітація, програма тренувань, динамометрія, диференційна діагностика, фізична терапія, адаптація м’язів.

**Introduction.** Grip strength is a critical indicator of neuromuscular function, occupational performance, and rehabilitation potential. It is widely used in clinical and sports science research as a measure of muscular adaptation, injury risk, and functional capacity. Individuals with Joint Hypermobility Syndrome (JHS) and hypermobile Ehlers-Danlos Syndrome (hEDS) often experience reduced joint stability altered proprioception, and impaired neuromuscular control, which may impact muscle strength and adaptation to resistance training [11; 20].

Differentiating between occupational and pathological hypermobility is crucial for understanding its role in grip strength development. Pathological hypermobility, as seen in JHS and hEDS, is associated with chronic pain, increased injury susceptibility, and neuromuscular dysfunction [4]. In contrast, occupational hypermobility, commonly observed in dancers, gymnasts, and circus performers, may provide a functional advantage in activities requiring increased joint range of motion [3]. However, the long-term effects of repetitive hypermobile joint stress on muscle strength development remain unclear [7]. While the professional requirements are that joint hypermobility can be beneficial for performance in activities like dance and acrobatics, meanwhile some research highlight its potential drawbacks, including musculoskeletal instability and an increased risk of overuse injuries [3; 5; 17].

Previous research has explored the biomechanical and injury-related implications of hypermobility, yet few studies have investigated its effect on muscle strength adaptation, particularly in different occupational settings [5; 8]. The Beighton score, commonly used for hypermobility assessment, is often supplemented with additional diagnostic tools such as the Grahame & Hakim questionnaire and Sachse’s criteria [4; 9; 10]. However, there is limited data on how hypermobility influences grip strength progression in individuals with varying occupational demands. Given the growing recognition of hypermobility-related musculoskeletal dysfunction, further research is needed to evaluate its effects on grip strength progression and neuromuscular stability.

This study aims to examine grip strength development over six months in individuals with and without hypermobility, specifically comparing professional circus performers and office workers. It is hypothesized that:

1. Hypermobility will be associated with lower baseline grip strength and slower adaptation to strength training.

2. Individuals with hypermobility will demonstrate a reduced neuromuscular response to resistance training, particularly those in non-athletic professions.

3. Circus performers will exhibit greater grip strength adaptation than office workers, highlighting the influence of occupational demands on muscle function.

By investigating grip strength progression across different hypermobility classifications, this study aims to contribute to differential diagnostics in muscle adaptation research and support the development of personalized strength training protocols for hypermobile individuals in clinical and performance settings.

**Materials and methods.** This study followed a longitudinal observational design to examine the effect of hypermobility on grip strength over six months. A total of 40 participants were recruited and divided into four groups based on occupation and hypermobility status:

− Group A – Circus performers with hypermobility

− Group B – Circus performers without hypermobility

− Group C – Office workers with hypermobility

− Group D – Office workers without hypermobility (control group)

Hypermobility was assessed using the Beighton score [4], the Grahame & Hakim questionnaire [10], and Sachse's criteria [16]. Participants were classified as hypermobile if they had a Beighton score of 5 or higher and a history of joint instability or related symptoms.

Grip strength was measured monthly over six months using a hand dynamometer, following a standardized testing protocol. To ensure reproducibility and consistency, a uniform hand positioning method was applied during all assessments. The best trial per hand was recorded and averaged to determine the mean grip strength per participant.

All participants followed a structured grip strength training program designed to improve muscle endurance and grip strength. The program included:

− Isometric and isotonic grip exercises using resistance grippers and bands;

− Dynamic squeezing exercises with stress balls and grip trainers;

− Finger flexion and extension exercises to strengthen hand muscles and improve joint stability.

In addition to grip strength measurements, joint stability was evaluated to assess potential neuromuscular constraints affecting grip strength adaptation. Neuromuscular control was analyzed based on observed force production efficiency and movement coordination during testing sessions.

Training sessions were conducted three times per week, lasting 20–30 minutes per session. The difficulty of the exercises increased gradually to ensure progressive strength development while considering the limitations of hypermobile individuals.

Descriptive statistics were used to summarize baseline grip strength and changes over time. One-way ANOVA was used to compare differences between groups, and paired t-tests assessed improvements within each group. Pearson correlation analysis was conducted to examine the relationship between baseline grip strength and improvement rates. A p-value $< 0.05$ was considered statistically significant.

**Study outcomes.** A significant difference in baseline grip strength was observed among the study groups ($p < 0.001$, ANOVA). Circus performers (Groups A and B) exhibited higher grip strength values in comparison to office workers (Groups C and D). The presence of hypermobility was associated with reduced baseline grip strength, a pattern evident in both circus performers with hypermobility (Group A) and office workers with hypermobility (Group C).

The calculation of baseline mean grip strength for each group was performed using the following formula (Fig. 1).

$$\text{Baseline Mean (kg)} = \frac{\sum(\text{Best Right Hand Trial} + \text{Best Left Hand Trial})}{\text{Number of Participants per Group}}$$

**Fig. 1. Calculation formula of baseline mean grip strength**

Based on this approach, Group B (Artists Without Hypermobility) demonstrated the highest baseline grip strength mean (100.83 ± 10.2 kg), whereas Group C (Office with Hypermobility) demonstrated the lowest values (47.02 ± 5.4 kg).

Grip strength increased across all groups over the course of the six-month intervention, although the magnitude of improvement varied significantly. Group B (Performers Without Hypermobility) demonstrated the most pronounced improvement (+20–25%), with grip strength increasing from 100.83 ± 10.2 kg to 124.18 ± 11.6 kg. Group A (Performers with Hypermobility) showed moderate gains (+10–15%), with values rising from 85.1 ± 9.6 kg to 95.8 ± 10.4 kg. Group C (Office with Hypermobility) demonstrated the smallest improvement (+5–8%), increasing from 47.02 ± 5.4 kg to 50.6 ± 5.9 kg. Group D (Office Without Hypermobility, Control Group) showed an increase of +10–12%, from 60.2 ± 6.1 kg to 70.5 ± 6.8 kg (Fig. 2).

A two-way analysis of variance (ANOVA) confirmed a significant effect of both group allocation and time interaction on grip strength progression ($p < 0.001$).

Pairwise t-tests were performed to further examine differences in grip strength improvement. Group B showed significantly greater improvements than all other groups ($p < 0.001$). Group C achieved significantly lower improvement rates compared to all other groups ($p < 0.01$). Although Groups A and B demonstrated comparable baseline values, their improvement trajectories diverged significantly over time ($p < 0.05$) (Fig. 3).

To further substantiate these findings, 95% confidence intervals (CIs) were calculated for each group. Group B (Performers Without Hypermobility) demonstrated the greatest improvement, with confidence intervals expanding from 80.06–121.60 kg at baseline to 98.55–149.81 kg after six months, confirming significant gains ($p < 0.001$). Group A (Performers with Hypermobility) showed moderate improvements, with a shift from 67.80–106.90 kg to 77.28–121.00 kg, indicating that hypermobility may limit strength progression compared to non-hypermobile circus performers. Group C (Office with Hypermobility) exhibited the smallest gain, with minimal expansion of confidence intervals (45.18–52.86 kg to 48.06–56.49 kg), reinforcing that occupational demand influences grip strength development. Group D (Office Without Hypermobility, Control) improved more than Group C, with confidence intervals expanding from 54.12–61.06 kg to 59.77–68.25 kg, but still demonstrating lower gains than the circus performer groups.

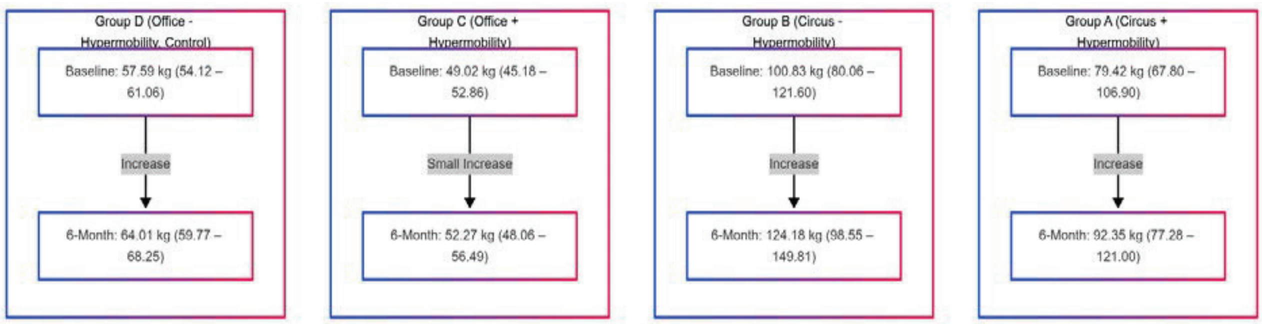


**Fig. 2. Grip strength improvement across all groups over the course of the six-month intervention**

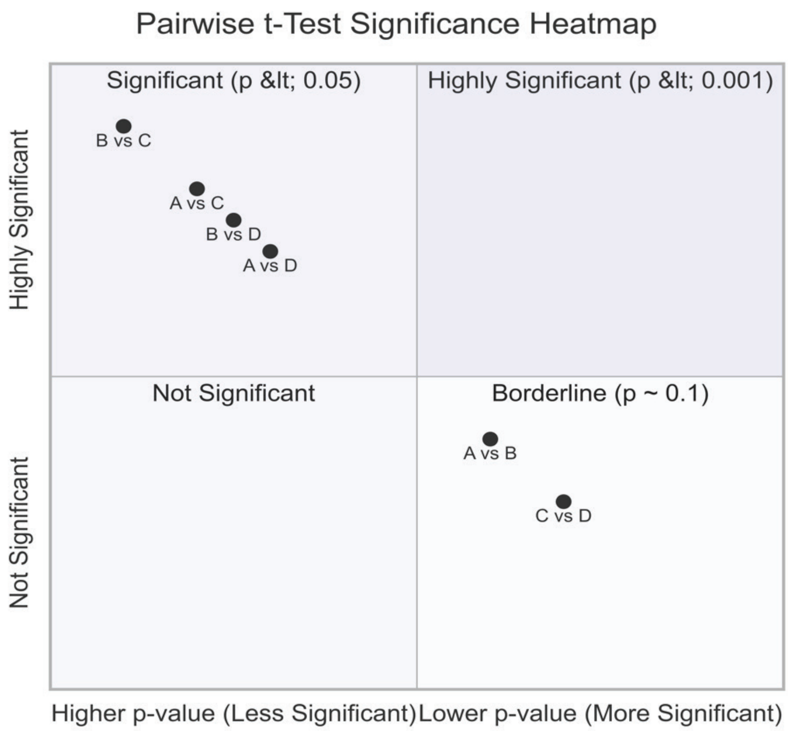


**Fig. 3. Pairwise t-Test significance heatmap**

A strong positive correlation (r = 0.85) was observed between baseline grip strength and percentage improvement, suggesting that individuals with higher initial grip strength tended to exhibit greater relative gains over the six-month training period.

**Discussion.** The present study aimed to investigate the effects of hypermobility on grip strength development over a six-month period in individuals with different occupational demands. The findings confirmed that circus performers (Groups A & B) had significantly higher baseline grip strength than office workers (Groups C & D), while hypermobility was associated with lower initial grip strength. The training intervention resulted in significant grip strength improvements across all groups, though the rate of progression varied. Group B (Performers Without Hypermobility) achieved the highest gains (+20–25%), whereas Group C (Office with Hypermobility) demonstrated the least improvement (+5–8%), reinforcing the influence of occupational and physiological factors on grip strength adaptation.

The results align with previous research indicating that joint hypermobility is associated with neuromuscular impairments, reduced proprioception, and decreased joint stability, which may limit strength development [14; 17; 19]. While circus performers with hypermobility (Group A) still showed moderate improvements (+10–15%), their progress was significantly lower than that of their non-hypermobile counterparts (Group B), suggesting that excessive joint laxity may reduce mechanical efficiency in force production.

In contrast, office workers with hypermobility (Group C) exhibited the lowest strength gains, which could be attributed to reduced baseline muscle engagement, less frequent exposure to load-bearing activities, or potential structural constraints. This supports previous findings that individuals with hypermobility, particularly those in sedentary occupations, may require targeted neuromuscular training programs to optimize muscle activation and strength progression [13; 16; 18].

Occupational demands played a critical role in grip strength development. Circus performers (Groups A & B) exhibited higher baseline values and greater training responses than office workers (Groups C & D), reinforcing the notion that muscular engagement in daily activities influences long-term strength adaptations. The significant improvement in Group B (Performers Without Hypermobility) suggests that individuals with greater initial neuromuscular control and joint stability may adapt more effectively to strength training protocols. Conversely, the relatively smaller improvements in office workers underscore the importance of structured strength training for non-athletic populations, particularly those with hypermobility.

Given the observed limitations in grip strength progression among hypermobile individuals, this study highlights the need for tailored strength training protocols that account for joint laxity, proprioceptive deficits, and muscular imbalances. Several key strategies may enhance training outcomes:

– Progressive neuromuscular stabilization training to improve joint control and muscle activation before increasing load intensity.

– Eccentric strengthening exercises to enhance tendon stiffness and joint stability, potentially improving force production efficiency.

– Individualized training regimens for hypermobile individuals, particularly those in non-athletic occupations, to address muscular imbalances and optimize adaptive responses.

**Conclusions.** The obtained results demonstrate a significant impact of hypermobility on grip strength development, with differences observed between occupational (adaptive) and pathological hypermobility. Individuals with adaptive hypermobility (circus performers) exhibited higher baseline grip strength and greater training adaptability, whereas pathological hypermobility (office workers with JHS/hEDS) was associated with lower baseline strength and a reduced ability to respond to grip strength training. These findings reinforce the role of occupational demands in shaping muscle function and adaptation capacity, highlighting the need for differentiated training strategies.

The study findings suggest that grip strength testing, combined with neuromuscular control assessments, could serve as a functional diagnostic tool for differentiating between occupational and pathological hypermobility. This approach may enhance clinical screening and rehabilitation strategies, enabling targeted interventions in physical therapy and sports medicine. Future research should explore the integration of grip strength dynamometry into routine hypermobility assessments, particularly in individuals at risk of musculoskeletal instability and functional impairments.

These findings support the development of structured, individualized training approaches tailored to both athletic and non-athletic hypermobile populations. By adopting evidence-based strength training strategies, clinicians, physiotherapists, and strength coaches can improve functional performance and mitigate injury risks in individuals with hypermobility.

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