Comparison of high-density and low-density neoprene knee sleeves on back squat and CMJ performance

Comparación de rodilleras de neopreno de alta y baja densidad en el rendimiento de sentadillas traseras y CMJ

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Abstract

Introduction: Neoprene knee sleeves are widely used as ergogenic aids in strength sports to enhance performance and reduce injury risk. High-density (HD) models have recently emerged, offering greater stiffness and support compared to traditional low-density (LD) sleeves.
Methods: This descriptive, comparative study included 19 trained males (18–35 years) who performed back squat and countermovement jump (CMJ) tests under both sleeve conditions (HD and LD) in a repeated-measures design. Performance variables included one-repetition maximum (1RM), mean propulsive velocity (MPV), jump height, and power.
Results: HD sleeves significantly improved 1RM compared to LD (mean difference = 5.45 kg; 95% CI [−8.13, −2.76]; p = 0.0005; ES = 0.26). No significant differences were found in MPV (β = 0.019 m/s, p = 0.31), jump height (β = −0.67 cm, p = 0.546), or power output (β = −12.5 W, p = 0.448).
Conclusions: HD sleeves enhanced maximal strength without significantly affecting velocity or jump performance. To our knowledge, this is the first study to directly compare HD and LD neoprene sleeves, providing novel evidence on the ergogenic impact of sleeve density in strength-trained individuals.

Keywords

CMJ; ergogenic tool; muscular performance; powerlifting; resistance training; vertical jump.

Resumen

Introducción: Las rodilleras de neopreno son ampliamente utilizadas como ayudas ergogénicas en deportes de fuerza para mejorar el rendimiento y reducir el riesgo de lesiones. Recientemente han surgido modelos de alta densidad (HD), que ofrecen mayor rigidez y soporte en comparación con las tradicionales de baja densidad (LD).
Métodos: Este estudio descriptivo comparativo incluyó a 19 hombres entrenados (18–35 años) que realizaron pruebas de sentadilla trasera y salto con contramovimiento (CMJ) bajo ambas condiciones de rodillera (HD y LD), en un diseño con medidas repetidas. Las variables evaluadas fueron el máximo de una repetición (1RM), la velocidad propulsiva media (MPV), la altura de salto y la potencia.
Resultados: Las rodilleras HD mejoraron significativamente el 1RM en comparación con las LD (diferencia media = 5,45 kg; IC 95% [−8,13; −2,76]; p = 0,0005; tamaño del efecto = 0,26). No se observaron diferencias significativas en la MPV (β = 0,019 m/s, p = 0,31), altura de salto (β = −0,67 cm, p = 0,546) ni potencia (β = −12,5 W, p = 0,448).
Conclusiones: Las rodilleras de alta densidad mejoraron la fuerza máxima sin afectar significativamente la velocidad ni el rendimiento en el salto. Hasta donde sabemos, este es el primer estudio que compara directamente rodilleras de neopreno de alta y baja densidad, aportando evidencia novedosa sobre el impacto ergogénico de la densidad del material en sujetos con experiencia en entrenamiento de fuerza.

Palabras clave

CMJ; ayuda ergogénica; rendimiento muscular; Levantamiento de potencia; Entrenamiento resistido; Salto vertical.

Introduction

The use of orthoses in strength training has gained increasing relevance due to their ergogenic potential in enhancing performance and preventing injuries across disciplines such as CrossFit, powerlifting, strongman, bodybuilding, and Olympic weightlifting (Mota & Marocolo, 2022; Rishiraj et al., 2009). Among these, powerlifting stands out as a sport that tests maximal strength through three lifts: the squat, bench press, and deadlift, with athletes performing up to three attempts in each (Córdoba, 2022). Executing a valid squat requires substantial knee flexion and extension, which places high mechanical stress on the joint (Harman, 1990; Pham et al., 2020). To mitigate this stress and enhance performance, athletes frequently use supportive equipment such as wraps or neoprene knee sleeves.

In the "Raw" division of powerlifting, 7-mm neoprene knee sleeves approved by the International Powerlifting Federation (IPF) are permitted during squat attempts, where lifters typically move loads at or near their one-repetition maximum (1RM) (Machek et al., 2021). Traditionally, these sleeves are made of low-density neoprene, a material that offers a balance between support and flexibility due to its structural composition (Gkouti et al., 2023). This combination allows athletes to maintain joint stability and mobility, thereby improving performance without compromising technique.

Over the last decade, equipment manufacturers have introduced high-density neoprene sleeves, which were officially added to the IPF's approved list on January 1, 2023. These models are significantly stiffer than their low-density counterparts (A7, n.d.; Inzer Advance Designs, n.d.; Iron Rebel, n.d.). Low-density neoprene contains a greater proportion of soft, elastic materials such as cotton or nylon, which enhances comfort and adaptability. In contrast, high-density neoprene is richer in rubber, increasing its stiffness and resistance to deformation (Yenigun et al., 2022). These structural distinctions affect key mechanical properties such as elongation at break and tensile response (Bouaziz et al., 2020).

In April 2025, the IPF Executive Committee announced the immediate removal of six specific high-density knee sleeve models from its approved equipment list, citing concerns regarding their stiffness. Athletes were permitted to use these sleeves until August 18, 2025, after which their use would be banned in all IPF-sanctioned competitions. The affected models included the INZER ErgoPro, Titan TKS 7mm, ONI Knee Sleeve Pro, Strength Shop Inferno PRO Extra Stiff, Fortex 7mm Extra Stiff, and A7 Hourglass Rigor Mortis sleeves.

However, following further deliberation, the IPF reversed this decision. Citing fairness to athletes and manufacturers, the Executive Committee reinstated the previously disqualified sleeves for use through the end of 2026. The IPF also announced plans to revise its Technical Rule Book and Equipment Manual and to develop a new standardized approval process for knee sleeves (International Powerlifting Federation [IPF], 2025).

Prior research has shown that using low-density neoprene knee sleeves can improve 1RM squat performance, with gains of approximately 6 kg when compared to lifting without sleeves (Machek et al., 2021). Additionally, studies indicate that both wraps and low-density sleeves may enhance vertical force production through elastic energy storage and release (Lake et al., 2012), while also improving the perceived stability of the knee joint (Sinclair et al., 2019). Despite these findings, no studies to date have directly compared the effects of high-density versus low-density neoprene sleeves on squat performance.

In elite strength sports, distinctions of a few kilograms can determine podium placements. Understanding whether high-density knee sleeves offer a meaningful performance advantage over traditional low-density models could inform decisions in both training and competition. Therefore, the purpose of this study was to compare the effects of high- and low-density neoprene knee sleeves on physical performance outcomes during the back squat and countermovement jump.

Method

This study employed a comparative descriptive cross-sectional design. Evaluations were conducted at a sports center located in Concepción, Chile. This study was reviewed and approved by the Institutional

Ethics Committee of Universidad Santo Tomás, Chile (Approval Code: 23-26). All procedures were conducted in accordance with the principles outlined in the Declaration of Helsinki. Prior to participation, all individuals received both written and verbal explanations about the study protocol, including potential risks and benefits, and voluntarily signed an informed consent form. Participants were informed of their right to withdraw from the study at any time without penalty.

Participants

Nineteen resistance-trained male participants (aged 18–35 years) were recruited through convenience sampling based on availability. Inclusion criteria required participants to (a) have a minimum of one year of consistent strength training experience (≥3 sessions per week), (b) demonstrate a back squat one-repetition maximum (1RM) equal to or exceeding 1.5 times their body weight, and (c) present a knee circumference between 35 and 38 cm, corresponding to size L knee sleeves per manufacturer specifications. Exclusion criteria included (a) current or recent use (within the past 12 months) of anabolic steroids, (b) musculoskeletal injury within the previous six months, and (c) adherence to voluntary caloric restriction during the testing period.

Although no a priori power analysis was conducted, a post hoc calculation was performed using the observed effect size for the primary outcome variable (1RM difference between conditions). Based on a paired-sample design, with an effect size of $d = 0.75$, an alpha level of 0.05, and 19 participant pairs, the calculated statistical power was $1 - \beta = 0.87$, indicating adequate power to detect moderate-to-large effects.

Procedure

Participants completed one familiarization session followed by two experimental sessions, each separated by 48 to 72 hours to ensure adequate recovery. During familiarization, they performed an incremental free-weight back squat protocol without knee sleeves. The test began at 50% of each participant's self-reported 1RM and progressed in load until reaching a bar velocity of approximately 0.5 m/s, as measured by a linear position transducer. This threshold corresponds to roughly 85% of maximal effort (Sánchez-Medina et al., 2017).

At the start of the second session, participants were randomly assigned to one of two experimental conditions—low-density (LD) or high-density (HD) knee sleeves—using a simple allocation method. Each participant drew a slip of paper from an opaque container (tómbola), determining the sleeve type to be used in that session. The alternate sleeve type was automatically assigned for the third session, thereby implementing a balanced crossover design.

Because the physical characteristics of the sleeves (e.g., stiffness, thickness) were easily distinguishable, blinding was not feasible. Both participants and assessors were aware of the condition being tested, which constitutes a limitation of the study design.

All participants used the same footwear and equipment across sessions and were instructed to replicate their usual lower-body warm-up routines to preserve ecological validity. Warm-ups were performed autonomously, following each participant's typical pre-training habits. The testing protocol remained identical across conditions to reduce potential bias. Additionally, during both the familiarization and experimental sessions, participants received real-time and ongoing feedback on bar velocity and were consistently encouraged to perform each repetition with maximal intentional effort (Weakley et al., 2021).

Data collection was conducted between January and June 2024.

Baseline Assessments

Before the physical performance evaluations, participants completed a questionnaire to collect sociodemographic information (age, years of strength training experience, training frequency, dietary habits, and use of ergogenic aids) and health history (comorbidities and previous musculoskeletal injuries). Body weight was assessed using a digital scale (Seca 803, Seca GmbH, Hamburg, Germany), and standing height was measured with a stadiometer (Seca 217, Seca GmbH, Hamburg, Germany).

Cuntermovement Jump

Jump performance was evaluated using a contact platform (Chronojump, Barcelona, Spain) to measure countermovement jump (CMJ) outcomes. During each attempt, participants aimed to maximize vertical displacement of the center of gravity through a rapid eccentric–concentric action involving hip, knee, and ankle flexion-extension, maintaining full extension of the lower limbs during the flight phase. Each participant completed three CMJ trials, with one minute of rest between attempts.

In accordance with the Bosco protocol (Bosco et al., 1983), the best performance from the three trials was used for analysis, registering both jump height (JH) and power output (P). The CMJ was selected due to its established validity and frequent application in research examining vertical jump performance in strength-trained populations (Sáez-Michea et al., 2023).

Data analysis

All statistical analyses were performed using RStudio software (version 2024.12.1+563). Descriptive data are reported as means and standard deviations. A post hoc power analysis was conducted based on the observed effect size for 1RM (Cohen's d = 0.75) and a sample size of 19, yielding a statistical power of 87% ($\alpha = 0.05$), which indicates sufficient sensitivity to detect moderate-to-large effects.

To account for the repeated-measures design, linear mixed-effects models were used instead of paired t-tests. Each model included condition (LD vs. HD) as a fixed effect and participant ID as a random intercept to control for inter-individual variability. P-values were calculated using Satterthwaite's method, and 95% confidence intervals (CIs) were estimated using the Wald method.

As no dropouts occurred, intention-to-treat analysis was not required. All results are reported with exact p-values and corresponding 95% CIs.

Results

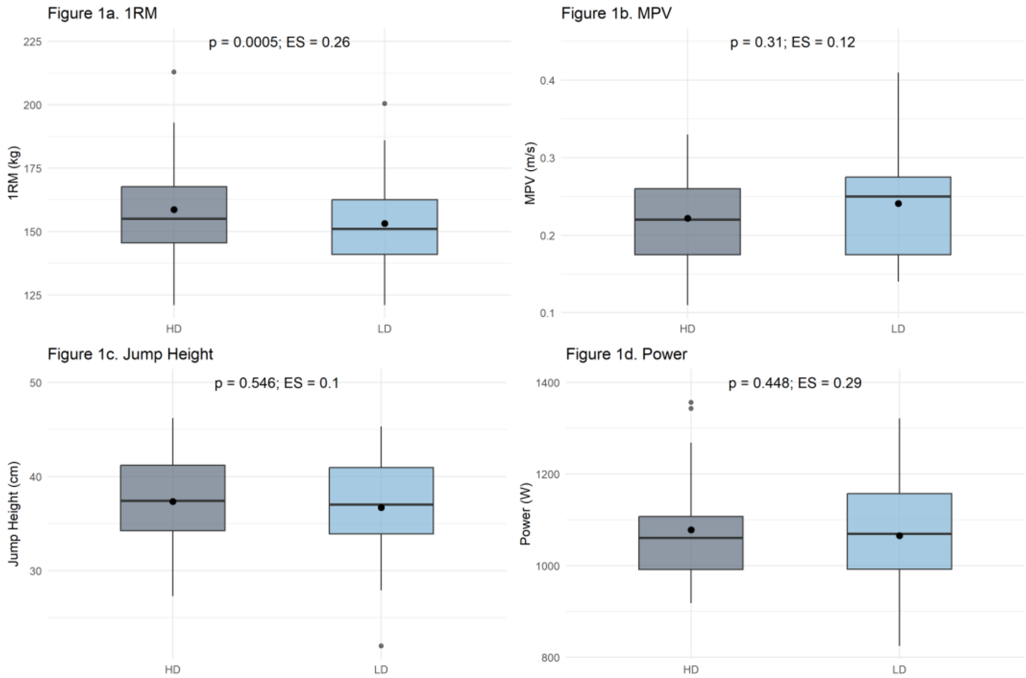
Table 1 presents the descriptive characteristics of the 19 study participants. The sample had a mean age of 26.84 ± 4.06 years, body weight of 82.11 ± 9.54 kg, and height of 1.73 ± 0.07 m. The average body mass index (BMI) was 27.11 ± 2.32 kg/m^2. Age ranged from 22 to 35 years, with body weights between 70.00 and 107.25 kg, and heights from 1.65 to 1.93 m. BMI values spanned from 23.40 to 31.83 kg/m^2. While this reflects some inter-individual variability in anthropometric characteristics, all participants met minimum strength and training experience requirements, providing a reasonably homogeneous sample of recreationally trained males. This profile supports the generalizability of the findings to strength-trained populations.

Table 1. General characteristics of the sample (n=19).

	Mean	SD	Max	Min
Age (years)	26.84	4.06	22	35
Weight (kg)	82.11	9.54	70.00	107.25
Height (m)	1.73	0.07	1.65	1.93
BMI (kg/m^2)	27.11	2.32	23.40	31.83

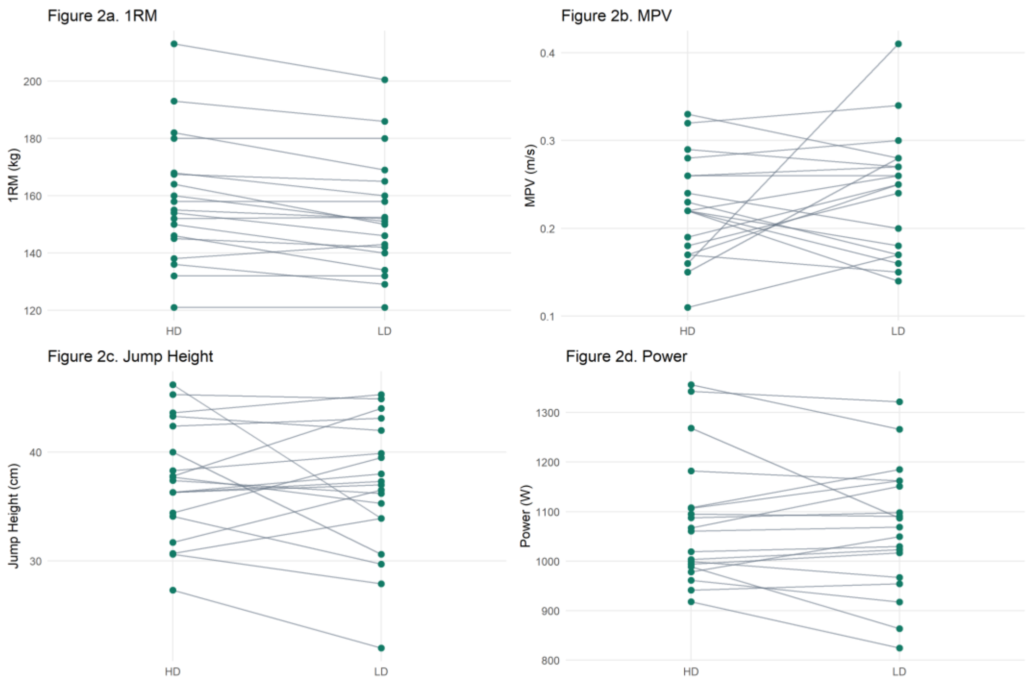
In back squat performance, a statistically significant difference in favor of high-density (HD) knee sleeves was observed for 1RM (p = 0.0005; ES = 0.258). Participants achieved a mean of 153.2 ± 20.28 kg with low-density (LD) sleeves and 158.7 ± 22.23 kg with HD sleeves (Figure 1a). For mean propulsive velocity (MPV) during 1RM execution, no significant difference was found between conditions (p = 0.310; ES = 0.117), with values of 0.241 ± 0.069 m/s for LD and 0.222 ± 0.058 m/s for HD sleeves (Figure 1b). Likewise, no significant differences were observed in jump height (p = 0.546; ES = 0.101), with means of 36.7 ± 6.15 cm and 37.4 ± 5.24 cm for LD and HD sleeves, respectively (Figure 1c). Power output also showed no significant variation between conditions (p = 0.448; ES = 0.294), with average values of 1065.4 ± 128.3 W for LD and 1077.9 ± 128.1 W for HD sleeves (Figure 1d).

Figure 1. Group-level comparisons between low-density and high-density knee sleeves across all performance variables.



Boxplots comparing performance outcomes between LD and HD knee sleeve conditions. Variables shown are: (a) one-repetition maximum (1RM), (b) mean propulsive velocity (MPV), (c) jump height, and (d) power output. Each box represents the interquartile range (IQR), with the horizontal line indicating the median. Whiskers denote 1.5 × IQR, and individual points outside the whiskers represent potential outliers. Black dots indicate group means. Reported *p*-values and effect sizes (ES) are derived from linear mixed-effects models accounting for repeated measures.

Figure 2. Individual responses to low-density (LD) and high-density (HD) knee sleeve conditions across all performance outcomes.



Individual response plots for each outcome variable comparing LD and HD knee sleeve conditions. Each line represents the performance of one participant across both conditions for: (a) one-repetition maximum (1RM), (b) mean propulsive velocity (MPV), (c) jump height, and (d) power. Colored dots represent individual scores per condition, and connecting lines indicate within-subject changes. These plots highlight the inter-individual variability in response to the intervention.

Table 2 summarizes the results and changes between LD and HD knee sleeves, focusing on the percentage differences in performance. Participants showed an average 3.5% improvement in 1RM (one-repetition maximum) with HD (158.66 ± 22.23 kg) compared to LD (153.21 ± 20.28 kg), equivalent to an absolute increase of 5.4 kg. Minimal changes were observed in jump height and jump power, with a 1.8% increase in jump height (37.35 ± 5.24 cm for HD vs. 36.68 ± 6.15 cm for LD) and a 1.2% increase in jump power (1077.88 ± 128.06 W for HD vs. 1065.37 ± 128.34 W for LD). Meanwhile, mean propulsive velocity during the 1RM execution decreased by 8.3% with HD (0.22 ± 0.06 m/s) compared to LD sleeves (0.24 ± 0.07 m/s). These results suggest that HD sleeves primarily enhance 1RM performance, while their impact on other variables, such as jump height and jump power, remains minimal.

Table 2. Results and changes between knee sleeves.

Variable	LD (Mean ± SD)	HD (Mean ± SD)	Change (kg/W/cm)	Change (%)
1RM (kg)	153.21 ± 20.28	158.66 ± 22.23	5.4	3.5
Mean Propulsive Velocity (m/s)	0.24 ± 0.07	0.22 ± 0.06	-0.02	-8.3
Jump Height (cm)	36.68 ± 6.15	37.35 ± 5.24	0.67	1.8
Jump Power (W)	1065.37 ± 128.34	1077.88 ± 128.06	12.51	1.2

Table 2. Comparison of physical performance variables obtained with LD and HD knee sleeves, including percentage and absolute changes in 1RM. 1RM refers to the one-repetition maximum in the back squat (kg); Mean Propulsive Velocity is the average concentric velocity at 1RM (m/s); Jump Height is the highest CMJ height achieved (cm); and Jump Power refers to the mechanical power during CMJ (W). Change columns represent absolute and relative differences between HD and LD conditions.

The 1RM was significantly higher when using HD sleeves (mean = 158.7 kg, 95% CI [147.9, 169.4]) compared to LD sleeves (mean = 153.2 kg, 95% CI [143.4, 163.0]). The mean difference between conditions was −5.45 kg (95% CI [−8.13, −2.76]; p = 0.0005), indicating a statistically significant improvement in maximal strength performance when using HD sleeves. Mean propulsive velocity (MPV) was slightly higher with LD sleeves (mean = 0.241 m/s, 95% CI [0.207, 0.275]) than with HD sleeves (mean = 0.222 m/s, 95% CI [0.194, 0.250]), but the difference was not statistically significant (β = 0.019 m/s, 95% CI [−0.017, 0.054]; p = 0.31). Jump height was also marginally lower with LD sleeves (mean = 36.7 cm, 95% CI [33.7, 39.6]) compared to HD sleeves (mean = 37.4 cm, 95% CI [34.8, 39.9]), with a non-significant difference of −0.67 cm (95% CI [−2.80, 1.46]; p = 0.546). Similarly, power output was slightly lower in the LD condition (mean = 1065.4 W, 95% CI [1003.5, 1127.2]) than in the HD condition (mean = 1077.9 W, 95% CI [1016.2, 1139.6]), but the difference did not reach statistical significance (β = −12.5 W, 95% CI [−44.1, 19.1]; p = 0.448). These findings suggest that while HD sleeves produced a meaningful enhancement in maximal strength (1RM), their effect on MPV, jump height, and power output was minimal and not statistically significant.

The linear mixed-effects models revealed a significantly lower one-repetition maximum (1RM) in the LD condition compared to the HD condition (β = −5.45 kg, 95% CI [−7.95, −2.94]; p = 0.0005), indicating enhanced strength performance when using HD knee sleeves. Although mean propulsive velocity (MPV) was slightly higher in the LD condition (β = 0.019 m/s), the difference was not statistically significant (95% CI [−0.017, 0.054]; p = 0.31). Similarly, estimated jump height was 0.67 cm lower in the LD condition compared to HD, but this difference also failed to reach statistical significance (β = −0.67 cm, 95% CI [−2.80, 1.46]; p = 0.546). Lastly, power output during the countermovement jump was marginally lower with LD sleeves (β = −12.5 W, 95% CI [−44.1, 19.1]; p = 0.448), suggesting minimal practical influence of sleeve density on explosive power.

Figure 3. Linear Mixed-effects model results.

Outcome Variable	Estimate (β)	95% CI	p-value	Interpretation
1RM (kg)	−5.45	[−7.95, −2.94]	0.0005	HD > LD; statistically significant
MPV (m/s)	0.019	[−0.017, 0.054]	0.31	No significant difference
Height (cm)	−0.67	[−2.80, 1.46]	0.546	No significant difference
Power (W)	−12.51	[−44.1, 19.1]	0.448	No significant difference

Note: Estimates reflect the difference in means between LD and HD conditions (LD relative to HD). A negative β indicates lower values with LD.

The difference in 1RM observed between conditions (mean difference = 5.45 kg; 95% CI [−8.13, −2.76]; p = 0.0005; ES = 0.258) was statistically significant. In the context of competitive powerlifting, where rankings and outcomes are determined by absolute kilograms lifted, such a performance improvement may carry meaningful implications. A 5.45 kg increase could influence podium placements, qualification totals, or even record attempts, particularly in closely contested weight classes. Therefore, despite the small effect size, the practical relevance of this gain should be considered substantial within this sport-specific framework.

Figure 4. Fixed effects estimates from linear mixed-effects models comparing performance outcomes between low- and high-density knee sleeves.

	1RM				MPV				Jump Height				Power			
Predictors	*Estimates*	*std. Error*	*CI*	*p*	*Estimates*	*std. Error*	*CI*	*p*	*Estimates*	*std. Error*	*CI*	*p*	*Estimates*	*std. Error*	*CI*	*p*
(Intercept)	158.66	4.88	-Inf – Inf	**<0.001**	0.22	0.01	-Inf – Inf	**<0.001**	37.35	1.31	-Inf – Inf	**<0.001**	1077.88	29.41	-Inf – Inf	**<0.001**
Condicion [LD]	-5.45	1.28	-Inf – Inf	**<0.001**	0.02	0.02	-Inf – Inf	0.303	-0.67	1.09	-Inf – Inf	0.542	-12.51	16.11	-Inf – Inf	0.443
Random Effects																
σ^2	15.50				0.00				11.19				2466.24			
τ_{00}	437.33 Sujeto				0.00 Sujeto				21.48 Sujeto				13969.26 Sujeto			
ICC	0.97				0.25				0.66				0.85			
N	19 Sujeto				19 Sujeto				19 Sujeto				19 Sujeto			
Observations	38				38				38				38			
Marginal R^2 / Conditional R^2	0.017 / 0.966				0.022 / 0.268				0.003 / 0.659				0.002 / 0.850			

Note. Estimates correspond to fixed effects comparing HD LD knee sleeves. Confidence intervals (CI) are based on a 95% level. Random intercepts were included for each participant to account for repeated measures. p-values were calculated using Satterthwaite's approximation. A negative estimate indicates lower values with HD sleeves compared to LD sleeves.

To explore relationships between anthropometric characteristics and performance outcomes, Pearson correlation analyses were conducted. Body weight showed negligible correlations with 1RM under both HD (r = 0.03, p = 0.899) and LD (r = −0.05, p = 0.843) conditions, suggesting that, within this trained sample, strength performance was not strongly influenced by body mass. Similarly, CMJ height exhibited only a weak correlation with 1RM in the HD condition (r = 0.17, p = 0.474); however, the association was moderate under the LD condition (r = 0.42, p = 0.077), albeit not statistically significant.

Height demonstrated a moderate positive correlation with MPV in the LD condition (r = 0.30, p = 0.205) and a negligible correlation with CMJ height (r = 0.01, p = 0.968). Interestingly, a strong and statistically significant correlation was observed between height and CMJ power output (r = 0.62, p = 0.005), suggesting that taller individuals may generate higher absolute power during vertical jumps.

Regarding body mass index (BMI), results indicated no meaningful relationship with MPV (r = 0.03, p = 0.908) or CMJ power (r = 0.29, p = 0.220). However, BMI was moderately and negatively correlated with

CMJ height (r = –0.47, p = 0.043), implying that individuals with higher BMI may achieve lower jump heights, potentially due to increased non-functional mass.

No subgroup analyses by training experience or sex were performed, as all participants were trained males with similar resistance training backgrounds.

Discussion

To our knowledge, this is the first study to directly compare the ergogenic effects of high-density (HD) knee sleeves with those of traditionally used low-density (LD) models in powerlifting. Our findings showed that HD sleeves significantly improved one-repetition maximum (1RM) performance, while no significant differences were observed in mean propulsive velocity (MPV), jump height, or power output. These results are consistent with those reported by Machek et al. (2021), who observed improvements in 1RM using 7-mm neoprene sleeves, without concurrent enhancements in muscular endurance or lower-body power metrics.

In contrast, Maynart et al. (2024) found that LD sleeves improved 1RM in the front squat when compared to a no-sleeve condition. This discrepancy may be attributed to differences in the control conditions: our study compared two types of sleeves, while Maynart et al. evaluated sleeves against a baseline without support. Furthermore, our assessment of lower-body power involved the countermovement jump (CMJ), a ballistic task with neuromechanical demands distinct from those of loaded squats. It is plausible that the rigidity of HD sleeves limited knee flexion during the eccentric phase, thereby reducing elastic energy storage and attenuating the contribution of the stretch-shortening cycle.

In this context, the improvement in 1RM observed with HD sleeves may be explained by two primary mechanisms: (a) enhanced kinesthetic awareness and reduced muscle oscillation, as previously described in the literature on supportive garments (Herrington et al., 2005; Sinclair et al., 2019; Maynart et al., 2024; Ghai et al., 2024); and (b) the storage and release of elastic energy in passive structures during the descent–ascent phases of the squat (Lake et al., 2012). These mechanisms, further supported by research on compression garments and neoprene aids (Lee et al., 2023; Saez-Berlanga et al., 2024), may facilitate vertical force transmission during the concentric phase of the lift.

Biomechanically, the additional joint stiffness provided by HD sleeves may influence the length-tension relationship of involved musculature, potentially enhancing force transmission by minimizing energy dissipation through soft tissues. However, this benefit may come at the cost of reduced range of motion and elastic pre-loading during dynamic tasks like jumping, which aligns with the lack of improvement observed in CMJ performance. Furthermore, based on the force–velocity–power relationship, it is possible that sleeves affect acceleration and velocity profiles differently depending on the movement pattern and external load, a hypothesis that merits further investigation.

The pressure and fit of the knee sleeves should also be considered. Excessively tight sleeves may impair proprioceptive input (Ramstrand et al., 2019) and alter squat mechanics (Lake et al., 2012), although this effect has not been consistently observed in trained lifters under submaximal loads (Eitner et al., 2011). In our study, we did not blind participants or evaluators due to the visible and tactile differences in sleeve stiffness, which constitutes a methodological limitation. Additionally, we did not perform test–retest reliability procedures, and as such, indices like intraclass correlation coefficients (ICC) or standard error of measurement were not calculated. This limits the ability to formally assess measurement stability across sessions.

Our findings are further constrained by the relatively small and homogeneous sample (trained young males), which limits the generalizability of results to female athletes, novice lifters, older adults, or clinical populations. Additionally, since the intervention involved a low training volume and isolated maximal and ballistic efforts, the results may not extend to chronic adaptations or high-volume training settings. Potential confounding factors such as individual comfort with different sleeve types, limb dominance, or prior experience with equipment were not controlled, and future studies should consider stratifying or adjusting for these variables.

Despite these limitations, the improvement in 1RM with HD sleeves (mean difference = 5.45 kg; ES = 0.258) is noteworthy. In competitive powerlifting, where rankings often hinge on absolute load lifted, even marginal gains may influence podium positions, qualification standards, or record-setting performances. Therefore, the practical relevance of this effect should be interpreted within the context of high-level sport.

Outside of powerlifting, the effects of joint compression and external support devices have also been explored in sports such as weightlifting, rugby, and basketball, with mixed findings. For instance, compression garments have been associated with improved proprioception and recovery, but not necessarily with enhanced performance (Ghai et al., 2024; Lee et al., 2023). This underscores the importance of context-specific evaluation when interpreting the effects of supportive equipment.

Finally, while some coaches have likened the performance of modern HD sleeves to that of knee wraps used in equipped powerlifting, this comparison is inappropriate. Wraps are applied under high tension by a third party and induce considerable joint compression, potentially altering movement mechanics. In contrast, the International Powerlifting Federation (IPF) requires that sleeves be self-applied without mechanical aids (IPF, 2024), making wrap-like compression incompatible with raw division standards.

Future research should investigate the chronic effects of high-density sleeves across different training volumes, intensities, and fatigue states. Studies involving female athletes, novice lifters, or alternative performance metrics such as electromyographic activity could provide additional insight into the neuromechanical impact of sleeve stiffness. Moreover, mechanistic investigations examining how sleeve compression influences joint kinetics, kinematics, and muscle activation across diverse movements (e.g., lunges, step-ups, Olympic lifts) would enhance understanding of the broader applicability and limitations of these supportive devices.

Conclusions

The present findings indicate that high-density neoprene knee sleeves significantly enhanced one-repetition maximum (1RM) performance compared to low-density models in trained individuals. However, no significant differences were observed in mean propulsive velocity or countermovement jump (CMJ) height between conditions. These results suggest that high-density sleeves may offer a performance benefit specifically for maximal strength tasks like the back squat, which could translate into a competitive advantage for powerlifters.

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