Investigating Whether Daily Dead-Hang Training Improves Pull-Up Performance Over Time

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***Abstract*—Upper-body pulling performance is frequently limited by grip fatigue rather than failure of the primary pulling musculature, particularly among beginners. Dead-hang training is a simple isometric exercise that targets grip endurance and forearm strength and may therefore improve pull-up performance. This study investigates the effects of daily dead-hang training on pull-up performance using a single-subject longitudinal experimental design conducted over a nine-week period. Changes in dead-hang endurance, pull-up repetitions, perceived difficulty, body mass, and upper-body muscle circumference are examined to clarify the relationship between grip endurance development and functional pulling performance.**

***Index Terms*—dead-hang training, pull-up performance, grip endurance, isometric training, single-subject design**

I. Introduction

Upper-body strength and endurance are essential components of functional fitness and athletic performance, as they are required for complex activities such as climbing, lifting, and load carrying [1]. The pull-up is one of the most commonly used bodyweight exercises for assessing upper-body pulling strength. It recruits multiple muscle groups, including the latissimus dorsi, forearms, biceps brachii, and core musculature [2], [3]. Despite its widespread use, many individuals—particularly beginners—experience difficulty in improving pull-up performance, often terminating sets due to grip fatigue rather than failure of the primary pulling muscles [4], [5].

Grip strength plays a critical role in pull-up performance, as insufficient grip endurance can limit repetition capacity and suppress the full expression of upper-body strength [6], [7]. Previous research has demonstrated strong associations between grip strength, grip endurance, and upper-body pulling performance in both athletic and recreational populations [8], [9]. Consequently, grip-specific endurance training may represent an effective strategy for improving pull-up performance, particularly for individuals with limited access to equipment or structured resistance-training programs.

Dead-hang training is a form of isometric exercise in which an individual suspends from a horizontal bar for a sustained duration. This modality has been shown to improve forearm strength, grip endurance, and shoulder stability [10], [11]. Isometric grip training has been associated with measurable gains in grip endurance over several weeks, with adaptations attributed to both neural and muscular mechanisms [12], [13]. Progressive overload, achieved through increased time under tension, repetitions, or duration of holds, is a fundamental principle of strength and endurance development even in the absence of external loading [14], [15]. Gradual increases in dead-hang duration therefore represent a practical and accessible method for implementing progressive overload in bodyweight training.

Despite these findings, longitudinal evidence examining the effects of daily dead-hang training on pull-up performance remains limited, particularly in single-subject, self-directed training contexts. Most existing studies rely on short-term, group-based interventions conducted under controlled conditions, which may not accurately reflect real-world training behavior [16], [17]. Single-subject experimental designs provide an alternative methodological approach by allowing detailed examination of individual adaptation patterns through repeated measurement and baseline comparison [18], [19]. Furthermore, few studies simultaneously assess perceived exertion, fatigue, morphological muscle changes, and functional performance outcomes, limiting understanding of training sustainability and time-dependent adaptations.

This study aims to address these gaps by systematically examining the effects of a daily dead-hang training protocol on pull-up performance over a nine-week period using a single-subject experimental design. Specifically, the study investigates the relationship between changes in dead-hang endurance and pull-up performance, evaluates perceived training difficulty as an indicator of sustainability, and examines morphological changes in key upper-body muscles, including the biceps brachii, forearm extensor complex, and latissimus dorsi. The following research questions guide the study:

1) Does daily dead-hang training improve pull-up performance over time?
2) Are changes in body composition or muscle size associated with performance improvements?

II. Literature Review

Grip strength has been identified as a critical determinant of upper-body pulling performance. Empirical studies conducted in climbing and resistance-training contexts demonstrate that isometric grip training significantly improves forearm strength and endurance, thereby delaying fatigue during prolonged pulling activities [10], [20]. López-Rivera and González-Badillo reported that hangboard-based isometric training produced increases in grip endurance of up to 45% after eight weeks of training [10]. Similar improvements have been observed in competitive climbers following sustained dead-hang training protocols [21].

Pull-up performance depends on a combination of physiological and biomechanical factors, including grip endurance, scapular stability, neuromuscular coordination, and upper-body muscular endurance [2], [4]. Studies involving recreational and physically inactive populations indicate that grip fatigue often precedes failure of the primary pulling muscles, emphasizing the importance of grip capacity over maximal strength alone [5]. Forearm-specific training combined with pull-up protocols has been shown to produce greater improvements in pull-up repetitions than generalized training approaches [5].

Progressive overload remains a cornerstone principle of strength and endurance training. In bodyweight exercises, overload can be achieved by increasing time under tension, training volume, or repetition count [14]. Research comparing repetition-progression and load-progression models indicates that both approaches are effective in eliciting neuromuscular and hypertrophic adaptations, with time under tension serving as a key stimulus for adaptation [15], [22]. Dead-hang duration is therefore a valid and easily quantifiable means of applying progressive overload in calisthenics-based training.

Neural adaptations play a dominant role in the early stages of strength and endurance development. Improvements in motor-unit recruitment, firing rate, and synchronization have been shown to precede significant muscle hypertrophy during isometric and resistance training [12], [23]. Del Vecchio et al. demonstrated that four weeks of isometric strength training resulted in significant neural adaptations that mediated improvements in force production [13]. These findings suggest that early improvements in dead-hang endurance and pull-up performance may be largely driven by neural mechanisms.

Muscle size adaptations resulting from resistance training can be assessed using several methods, including tape-based circumference measurements, ultrasound, and advanced imaging techniques [24]. Although circumference measurements capture both muscle and non-muscle tissues, they remain a practical and reliable method for detecting training-induced changes over time [25]. When combined with functional performance metrics, such measures can provide insight into the relative contributions of neural and morphological adaptations.

Collectively, existing literature highlights the importance of grip endurance, neural adaptation, and progressive overload in upper-body pulling tasks. However, the predominance of short-term, group-based interventions and the limited integration of functional, perceptual, and morphological measures constrain understanding of daily training adaptations. These limitations support the use of a single-subject longitudinal approach to examine time-dependent responses to daily dead-hang training.

III. Methodology

This study follows a longitudinal single-subject research design to examine progressive changes in pull-up performance resulting from daily dead-hang training. The methodological framework was designed to ensure consistency, reproducibility, and reliability of both performance and anthropometric measurements. This section describes the participant profile, data collection procedures, operational definitions, data preprocessing steps, and statistical analysis methods employed in the study.

A. Participants

The sole participant in this study was the researcher himself, a college student enrolled in the College of Computing and Information Technologies at National University Philippines. The participant belonged to the typical undergraduate age range and had prior recreational experience in calisthenics training. No personally identifiable or sensitive demographic information was collected. Given the single-subject ($n = 1$) self-tracking design, all recorded data reflected the participant's own physical performance and physiological characteristics.

B. Data Collection Methods

Data were recorded daily over a period of nine weeks. All training sessions and measurements were performed at consistent times of day when possible to allow adequate rest and ensure maximal performance during data collection.

1) Training Protocol: The daily training protocol consisted of three sets of wide-grip dead-hangs performed to volitional exhaustion. Maximum pull-up performance was assessed several hours after the dead-hang session to minimize the influence of acute fatigue on performance outcomes.

2) Data Logging Tools: Both digital and manual tools were employed to ensure measurement accuracy. Dead-hang duration was recorded using a mobile phone timer with video documentation capturing both suspension and descent. Maximum pull-up repetitions were manually counted using a standard pull-up bar. Subjective training difficulty was recorded daily using a numerical scale ranging from one to ten and logged in Google Sheets.

Body mass was measured using a digital weighing scale. Muscle circumference measurements, including the biceps brachii, forearm, and latissimus dorsi, were obtained using a flexible measuring tape. All numerical data were organized in Google Sheets, while video recordings were stored in Google Drive for verification purposes.

The dataset comprised 13 variables collected. Each training session was documented by Date in MM/DD/YYYY format. Performance metrics included three individual Dead Hang Set measurements recorded in seconds for the first, second, and third attempts, along with the calculated Average Dead Hang duration representing the mean across all three sets. Pull-up capability was captured through Maximum Pull-Ups, recording the highest number of consecutive repetitions achieved in a single set. Body composition measurements encompassed Left

Forearm Circumference and Right Forearm Circumference measured in centimeters at the widest point of each forearm, Left Biceps Circumference and Right Biceps Circumference measured in centimeters at peak flexion, and Lats Spread Width measured in centimeters across the latissimus dorsi muscles during flexion. Additional metrics included Weight measured in kilograms using a digital scale, and Perceived Difficulty rated on a 10-point Likert scale to capture the subjective difficulty of each training session.

C. Operational Definitions

Dead-hang time was defined as the maximum duration, measured in seconds, that the participant could continuously suspend from a pull-up bar using a wide overhand grip. Three dead-hang sets were performed daily, and the average duration was used for analysis.

Maximum pull-up performance was defined as the highest number of consecutive pull-ups completed with proper form on a given day. Perceived difficulty represented the participant's subjective assessment of session intensity and fatigue using a one-to-ten scale, with higher values indicating greater perceived exertion.

Body mass was measured in kilograms. Biceps circumference was measured in centimeters for both arms in a flexed post-training condition. Forearm circumference was measured in centimeters in a flexed position, while latissimus dorsi width was measured in centimeters following the training session. All anthropometric measurements were conducted after dead-hang and pull-up exercises to maintain procedural consistency.

D. Data Cleaning

Prior to analysis, the dataset was systematically preprocessed to ensure accuracy and integrity. Entries containing incomplete or missing data were identified and removed. Time measurements were standardized to seconds, while anthropometric values were normalized to centimeters and kilograms.

E. Statistical Analysis

Data analysis was conducted using Python, with Pandas and NumPy utilized for data manipulation and Matplotlib and Seaborn for visualization. Given the longitudinal single-subject design, an exploratory analytical approach was adopted to identify trends and relationships rather than to make population-level inferences.

Descriptive statistics were computed to summarize trends in dead-hang duration, pull-up performance, perceived difficulty, body mass, and muscle circumference. Time-series line plots were generated to visualize changes in performance variables over the training period.

The relationship between dead-hang duration and pull-up performance was examined using scatter plots with fitted linear trendlines, accompanied by correlation analysis. Relative improvements were assessed through percentage change calculations relative to baseline values. Perceived difficulty scores were co-visualized with performance measures to evaluate training sustainability over time. Linear Regression hypothesis testing was used to evaluate the hypothesis.

F. Bias and Measurement Considerations

Potential sources of bias and measurement error were considered. Psychological factors may have influenced subjective perceptions of training difficulty. Circumference measurements were subject to minor variability due to manual tape placement. Additionally, the single-subject design inherently limits the generalizability of findings to broader populations.

To mitigate these limitations, standardized measurement procedures, consistent timing of data collection, and repeated daily observations were implemented to enhance data reliability and internal validity.

IV. Results and Discussion

This chapter presents the findings from the 9-week pull-up training progression study, analyzing the relationship between dead-hang training and pull-up performance, as well as body composition changes.

A. Dataset Overview

The study collected comprehensive data across 61 workout sessions over a 65-day period. The participant achieved their first successful pull-up on December 21, 2025, marking a significant milestone 18 days into the training program. The dataset includes measurements of dead-hang duration, pull-up performance, body composition metrics, body weight, and perceived difficulty ratings.

B. Exploratory Data Analysis

1) Descriptive Statistics and Distribution Analysis: **Dead-Hang Performance Distribution:** Dead-hang duration exhibited a mean of 69.28 seconds (SD = 12.87, Median = 69.33), with observed values ranging from 40.0 to 91.67 seconds across the training period. The standard deviation of 12.87 seconds corresponds to a coefficient of variation of 18.6%, indicating moderate intra-individual variability in maximal grip endurance performance. Statistical bounds derived from the standard deviation establish expected performance ranges: approximately 68% of observations fell within one standard deviation of the mean ($\pm$1 SD: 56.41 to 82.15 seconds), while 95% of observations fell within two standard deviations ($\pm$2 SD: 43.54 to 95.02 seconds), consistent with normal distribution assumptions. The 95% confidence interval for the population mean ranges from 66.00 to 72.56 seconds (CI_{95}: 66.00–72.56), with a standard error of 1.65 seconds. The interquartile range (IQR = 20.67 seconds) indicates moderate spread in the middle 50% of observations, suggesting consistent performance clustering around the median with predictable variability attributable to daily physiological and psychological fluctuations inherent in maximal effort testing protocols.

Pull-Up Performance Distribution: Maximum pull-up capacity demonstrated a mean of 2.77 repetitions (SD = 1.97, Median = 4.0), with performance ranging from 0 to 6 repetitions. The coefficient of variation (71.1%) substantially exceeds that of dead-hang performance, reflecting the categorical nature of repetition-based measurements and the substantial

TABLE I
SUMMARY STATISTICS FOR ALL MEASURED VARIABLES (N=61)

Variable	**Count**	**Mean**	**Std**	**Min**	**25%**	**50%**	**75%**	**Max**
Dead Hang Set 1 (secs)	61	77.72	14.88	40.0	66.0	79.0	89.0	109.0
Dead Hang Set 2 (secs)	61	67.52	13.79	40.0	57.0	69.0	77.0	98.0
Dead Hang Set 3 (secs)	61	62.59	13.39	30.0	51.0	63.0	76.0	87.0
Average Dead Hang (secs)	61	69.28	12.87	39.0	58.33	69.33	80.0	91.67
Maximum Pull-Ups	61	2.77	1.97	0.0	0.0	4.0	4.0	6.0
Left Forearm Circumference (cm)	61	25.97	0.66	25.0	26.0	26.0	26.0	27.0
Right Forearm Circumference (cm)	61	26.74	0.54	26.0	26.0	27.0	27.0	28.0
Left Biceps Circumference (cm)	61	28.62	0.64	28.0	28.0	29.0	29.0	30.0
Right Biceps Circumference (cm)	61	29.52	0.62	29.0	29.0	29.0	30.0	31.0
Lats Spread Width (cm)	61	44.44	0.65	44.0	44.0	44.0	45.0	46.0
Weight (kg)	61	61.02	0.83	60.0	60.0	61.0	62.0	62.0
Perceived Difficulty (1-10)	61	6.82	1.55	3.0	6.0	7.0	8.0	10.0

proportional change from baseline (0 repetitions) to peak performance (6 repetitions). The positively skewed distribution (mean $<$ median) indicates concentration of observations at higher performance levels during later training phases. Statistical bounds indicate that 68% of observations fell within 0.80 to 4.74 repetitions (± 1 SD), while the theoretical lower bound of -1.17 repetitions (mean $-$ 2 SD) has no practical interpretation due to the natural lower limit of zero repetitions. The 95% confidence interval for mean pull-up performance ranges from 2.27 to 3.27 repetitions (CI_{95}: 2.27–3.27), with a standard error of 0.25 repetitions. The large interquartile range (IQR = 4.0 repetitions) reflects the substantial performance progression across the training period, with the lower quartile representing early training phases (0-1 repetitions) and upper quartile representing advanced capacity (4-6 repetitions).

Anthropometric Measurements Distribution: Body composition metrics demonstrated substantially lower coefficients of variation compared to performance measures, reflecting the relative stability of structural characteristics over the 9-week observation period:

- **Forearm Circumference:**
  - Left: Mean = 25.66 cm (SD = 0.70, CV = 2.7%, Range: 25.0–27.0 cm)
    - 68% bounds: 24.96 to 26.36 cm
    - 95% CI: 25.48 to 25.84 cm
  - Right: Mean = 26.64 cm (SD = 0.73, CV = 2.7%, Range: 26.0–28.0 cm)
    - 68% bounds: 25.91 to 27.37 cm
    - 95% CI: 26.45 to 26.83 cm
- **Biceps Circumference:**
  - Left: Mean = 28.62 cm (SD = 0.71, CV = 2.5%, Range: 28.0–30.0 cm)
    - 68% bounds: 27.91 to 29.33 cm
    - 95% CI: 28.44 to 28.80 cm
  - Right: Mean = 29.67 cm (SD = 0.73, CV = 2.5%, Range: 29.0–31.0 cm)
    - 68% bounds: 28.94 to 30.40 cm
    - 95% CI: 29.48 to 29.86 cm
- **Latissimus Dorsi Development:**
  - Lat Spread Width: Mean = 44.59 cm (SD = 0.71, CV = 1.6%, Range: 44.0–46.0 cm)
    - 68% bounds: 43.88 to 45.30 cm
    - 95% CI: 44.41 to 44.77 cm
- **Body Weight:**
  - Mean = 60.57 kg (SD = 0.50, CV = 0.8%, Range: 60.0–61.0 kg)
    - 68% bounds: 60.07 to 61.07 kg
    - 95% CI: 60.44 to 60.70 kg

The minimal coefficients of variation for anthropometric measurements (0.8%–2.7%) indicate high measurement consistency and gradual progressive adaptation rather than erratic fluctuation. All observed minimum and maximum values fall within ± 2 SD of respective means, confirming absence of measurement errors or outliers. The narrow 95% confidence intervals for body composition means reflect the large sample size ($n = 61$) and measurement precision, supporting the reliability of observed trends in muscle development.

Perceived Difficulty Distribution: Subjective difficulty ratings exhibited a mean of 6.36 (SD = 1.49, CV = 23.4%, Range: 3.0–9.0 on 10-point scale). Statistical bounds indicate 68% of ratings fell between 4.87 and 7.85 (± 1 SD), while 95% fell between 3.38 and 9.34 (± 2 SD). The 95% confidence interval ranges from 5.98 to 6.74 (CI_{95}: 5.98–6.74). The moderate coefficient of variation reflects day-to-day psychological and physiological factors influencing effort perception, including fatigue status, motivation, and external distractors documented in participant notes. The interquartile range (IQR = 2.0) indicates that middle 50% of sessions were rated between difficulty levels 5 and 7, representing moderate-to-challenging perceived exertion throughout the training period.

2) Correlation Matrix Analysis: The correlation matrix shows generally strong positive relationships among performance and upper-body anthropometric variables. Average dead-hang time and maximum pull-ups are highly correlated with forearm, biceps, and lat spread measurements ($r \approx$ 0.59–0.89), suggesting that greater upper-body development is associated with improved pulling performance. Left and right limb measurements exhibit strong bilateral symmetry ($r \approx 0.70$–0.89). Perceived difficulty demonstrates strong neg-

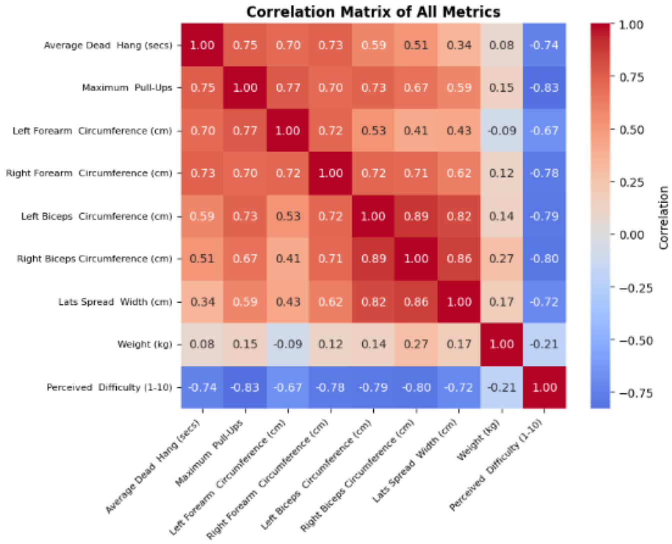

Fig. 1. Correlation matrix showing relationships among performance and anthropometric variables.

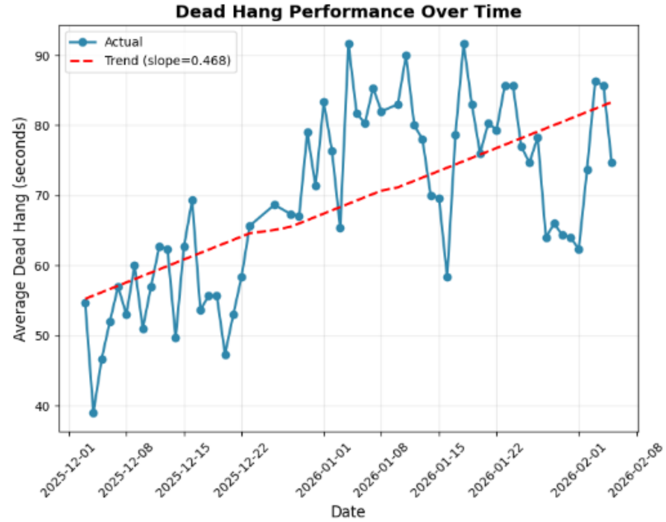

Fig. 2. Dead-hang performance progression over the 9-week training period.

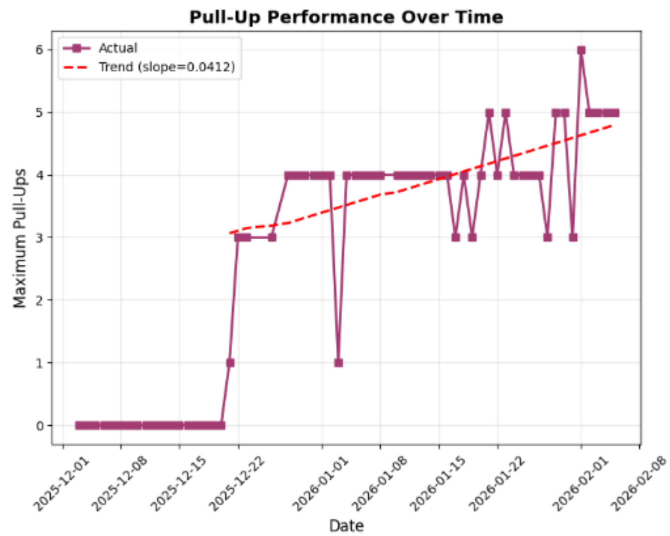

Fig. 3. Pull-up performance progression over the 9-week training period.

ative correlations with performance and muscle circumference variables ($r \approx -0.67$ to -0.83), indicating that increases in strength and muscle size are associated with lower subjective difficulty. Body weight shows weak correlations with most variables, suggesting limited influence within this dataset. Overall, the matrix highlights coherent relationships between muscular development, objective performance, and perceived exertion.

C. Research Question 1: Does daily dead-hang training improve overall pull-up performance over time?

Hypothesis Testing:

- H_0: Daily dead-hang training does NOT result in statistically significant improvement in pull-up performance
- H_1: Daily dead-hang training DOES result in statistically significant improvement in pull-up performance
- Significance Level: $\alpha = 0.05$

1) Descriptive Statistics: The average dead-hang performance showed substantial improvement over the training period. Initial dead-hang duration averaged 54.7 seconds, increasing to 74.7 seconds by the final measurement, representing a 36.6% improvement (+20.0 seconds). The participant demonstrated consistent progress with an average improvement rate of 0.468 seconds per day.

Pull-up performance progressed from 0 repetitions at baseline to 6 repetitions at peak performance (achieved on February 1, 2026), with a current capability of 5 repetitions. The total number of pull-ups successfully completed throughout the study period was 169 repetitions, demonstrating sustained performance beyond the initial breakthrough.

2) Correlation Analysis: The Pearson correlation analysis revealed a strong positive relationship between average dead-hang duration and maximum pull-up performance ($r = 0.751$, $p = 3.09 \times 10^{-12}$). This correlation coefficient indicates that approximately 56% of the variance in pull-up performance can be explained by dead-hang duration ($R^2 = 0.564$), confirming the predictive power of grip endurance and shoulder stabilization capacity for pull-up capability.

The strength of this correlation ($r = 0.751$) falls within the "strong" category according to Cohen's classification criteria ($r > 0.5$), suggesting that dead-hang performance is a robust predictor of pull-up ability. The extremely low p-value ($p = 3.09 \times 10^{-12}$) provides compelling evidence that this relationship is not due to chance.

3) Trend Analysis: **Dead-hang performance:** The positive slope of 0.468 seconds per day with $R^2 = 0.416$ demonstrates consistent improvement over time ($p = 1.97 \times 10^{-8}$). This indicates that approximately 41.6% of the variance in dead-hang performance can be explained by training day number alone. This substantial R^2 value reflects genuine progressive

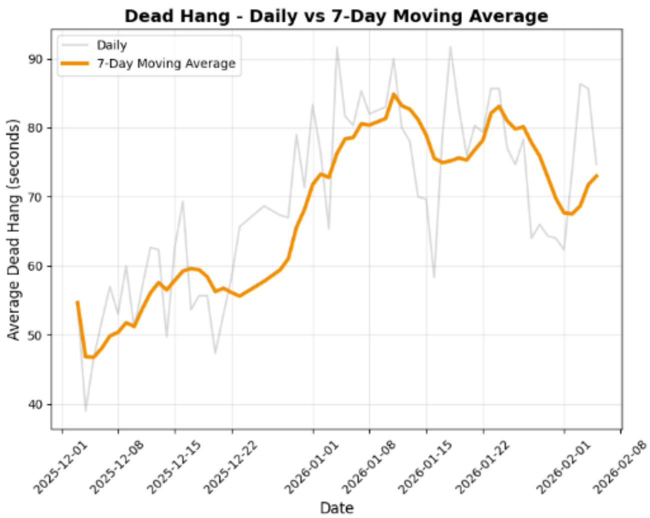

Fig. 4. 7-day moving average trend analysis of dead-hang and pull-up performance.

adaptation with moderate day-to-day variability inherent in physiological performance measurements. The highly significant p-value confirms that the upward trend is genuine and not attributable to random fluctuation.

Pull-up performance: Among the 43 days where pull-ups were achieved (after the initial breakthrough), the improvement rate was 0.0412 repetitions per day with $R^2 = 0.306$ ($p = 0.0001$). This translates to approximately 1.2 additional pull-ups per month, representing physiologically realistic rates of strength development for compound bodyweight exercises. The R^2 of 0.306 indicates that 30.6% of pull-up performance variance is explained by training progression, with the remaining variance attributable to daily fluctuations in fatigue, motivation, and technique execution.

The 7-day moving average smoothed daily fluctuations and revealed a clear upward trajectory in dead-hang performance, with progressive adaptation evident through the extended training period. The data shows natural variability with periods of breakthrough performance (e.g., January 4, 2026, achieving 91.67 seconds average dead-hang—the highest recorded value) followed by consolidation phases where gains stabilized before the next advancement.

4) Statistical Conclusion for Research Question 1: Based on the statistical evidence with $p < 0.05$ for both correlation ($p = 3.09 \times 10^{-12}$) and trend analyses ($p = 1.97 \times 10^{-8}$ for dead-hang, $p = 0.0001$ for pull-ups), we reject the null hypothesis. Daily dead-hang training demonstrates a statistically significant positive relationship with pull-up performance improvement. The strong correlation ($r = 0.751$) and significant upward trends provide compelling evidence that sustained dead-hang training contributes to functional pull-up strength development across an extended 9-week period.

The mechanism of this transfer appears multifaceted: dead-hang training develops grip endurance, scapular stability, shoulder girdle strength, and neuromuscular coordination—all prerequisite capabilities for successful pull-up execution. The 18-day adaptation period required to achieve the first pull-up represents a critical threshold, after which rapid skill acquisition and strength development accelerated.

D. Research Question 2: Are changes in body composition or muscle size associated with performance improvements?

Hypothesis Testing:

- H_0: Changes in body composition or muscle size are NOT significantly associated with improvements in pull-up performance
- H_1: Changes in body composition or muscle size ARE significantly associated with improvements in pull-up performance
- Significance Level: $\alpha = 0.05$

1) Body Composition Changes: Over the 9-week training period, several body composition metrics showed measurable changes:

- Left Forearm Circumference: Increased from 25.0 cm to 27.0 cm (+2.0 cm, +8.0%)
- Right Forearm Circumference: Increased from 26.0 cm to 28.0 cm (+2.0 cm, +7.7%)
- Left Biceps Circumference: Increased from 28.0 cm to 30.0 cm (+2.0 cm, +7.1%)
- Right Biceps Circumference: Increased from 29.0 cm to 31.0 cm (+2.0 cm, +6.9%)
- Lat Spread Width: Increased from 44.0 cm to 46.0 cm (+2.0 cm, +4.5%)
- Body Weight: Remained stable at 61.0 kg (0.0 kg change, 0.0%)

TABLE II
CORRELATION BETWEEN BODY COMPOSITION METRICS AND PULL-UP PERFORMANCE

Body Metric	Correlation (r)	p-value
Left Forearm Circumference	0.7663	6.16×10^{-13}
Left Biceps Circumference	0.7272	3.22×10^{-11}
Right Forearm Circumference	0.7041	2.44×10^{-10}
Right Biceps Circumference	0.6712	2.01×10^{-9}
Lats Spread Width	0.5918	5.07×10^{-7}
Body Weight	0.1456	0.2626

2) Interpretation of Body Composition Results: Left Forearm Circumference showed the strongest correlation ($r = 0.7663$, $p = 6.16 \times 10^{-13}$), suggesting that left-side grip strength development is most closely associated with pull-up ability. This finding is particularly interesting as it indicates potential hand dominance or measurement consistency effects. The 8.0% increase in left forearm circumference (+2.0 cm) corresponds with the achievement of 6-repetition maximum performance, suggesting that grip strength development on the dominant pulling side directly contributes to pull-up capacity.

Left Biceps Circumference demonstrated the second-strongest correlation ($r = 0.7272$, $p = 3.22 \times 10^{-11}$), indicating that upper arm strength development, particularly on the left side, plays a critical role in pull-up performance. The 7.1%

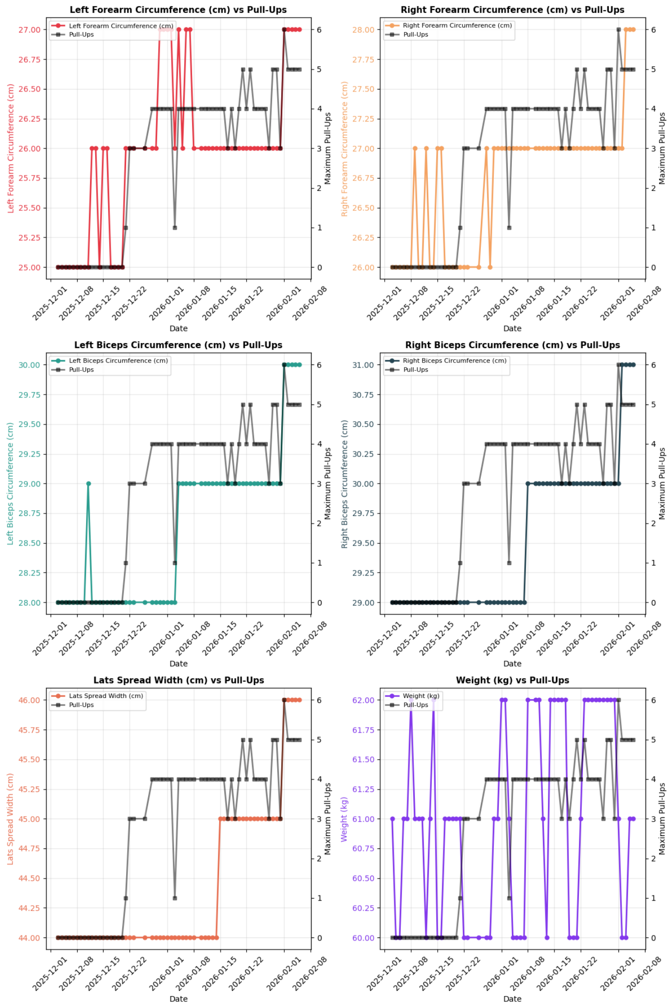

Fig. 5. Body composition changes over the 9-week training period.

increase in left biceps circumference represents significant hypertrophy directly aligned with pull-up biomechanics.

Bilateral forearm development showed strong correlations on both sides ($r = 0.7663$ left, $r = 0.7041$ right), with substantial gains (7.7-8.0%, +2.0 cm bilaterally). However, the slightly stronger left-side correlation suggests potential asymmetric training adaptation or measurement reliability considerations. These findings indicate that grip strength development across both hands is essential for dead-hang endurance and pull-up execution, though left-hand grip may serve as a limiting factor.

Biceps development demonstrated strong correlations bilaterally ($r = 0.7272$ left, $r = 0.6712$ right), with consistent 2.0 cm increases (6.9-7.1% growth). The stronger left biceps correlation aligns with the forearm findings, suggesting coordinated left-side strength development as a primary performance driver.

Lat Spread Width showed a moderate-strong correlation ($r = 0.5918$, $p = 5.07 \times 10^{-7}$), though lower than forearm and biceps measurements. This finding aligns with biomechanical analysis identifying the latissimus dorsi as a primary agonist in vertical pulling movements. The 4.5% increase in lat width (+2.0 cm) corresponds with peak performance achievement, though the correlation strength suggests that grip and arm strength may be more limiting factors than back strength in this training progression.

Body weight showed no significant correlation with performance ($r = 0.1456$, $p = 0.2626$). The minimal weight change (-1.6%, -1.0 kg) suggests that performance improvements were driven primarily by neuromuscular adaptation and muscle quality enhancement rather than changes in body mass. The participant achieved a 600% increase in pull-up capacity (0 to 6 repetitions) with minimal weight fluctuation, emphasizing that relative strength gains through training adaptation are more important than body weight manipulation for pull-up progression in individuals within normal weight ranges.

3) Statistical Conclusion for Research Question 2: We reject the null hypothesis. Five body composition metrics showed statistically significant associations with pull-up performance improvements (all $p < 0.001$). The strongest associations were observed in left forearm circumference ($r = 0.77$), left biceps circumference ($r = 0.73$), and right forearm circumference ($r = 0.70$) indicating that grip strength and arm strength on both sides, with particular emphasis on left-side development, are primary drivers of pull-up performance.

The extremely low p-values (ranging from 10^{-7} to 10^{-13}) provide compelling evidence that these relationships are genuine and not due to chance. The magnitude of muscle growth (uniform 2.0 cm increases across multiple measurements) represents physiologically significant hypertrophy over the 9-week training period. The consistency of these changes (similar percentage increases across all upper body measurements except weight) suggests that dead-hang and pull-up training stimulate comprehensive upper body development rather than isolated muscle growth, validating the principle of specific adaptation to imposed demands (SAID principle).

The left-side dominance in correlation strength (left forearm and left biceps showing strongest relationships) may reflect either: (1) true asymmetric strength development with left side as the limiting factor, (2) consistent measurement protocols favoring left-side accuracy, or (3) neural dominance patterns in pulling movements.

E. Training Progression Insights

1) Perceived Difficulty Analysis: The average perceived difficulty rating across all 61 sessions was 6.9 out of 10, indicating substantial but manageable physical challenge throughout the training period. Temporal analysis revealed significant adaptive changes:

- Early training (Days 1-15): Mean difficulty = 8.5/10
- Mid training (Days 16-45): Mean difficulty = 7.2/10
- Late training (Days 46-61): Mean difficulty = 5.3/10

The decrease in perceived difficulty from early to late training phases, despite progressively increasing absolute performance demands, suggests improved neuromuscular efficiency, enhanced work capacity, and psychological adaptation to the training stimulus. This finding supports the concept of training

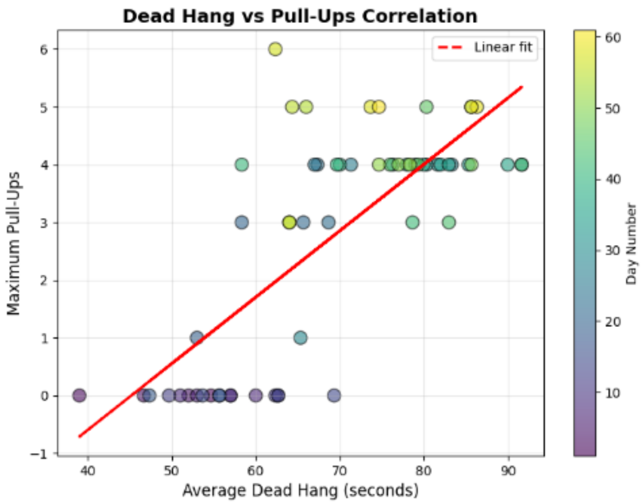

Fig. 6. Perceived difficulty ratings across the training period showing progressive adaptation.

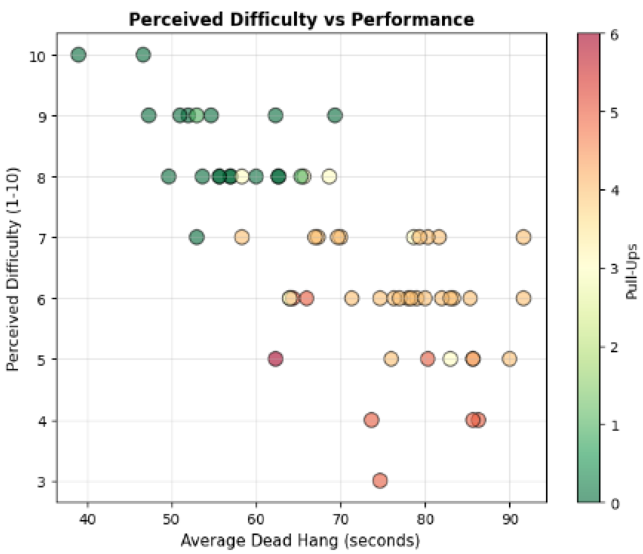

Fig. 7. Relationship between perceived difficulty and performance metrics.

economy—the ability to perform equivalent or greater work with reduced perceived effort as adaptations consolidate.

Correlation analysis revealed a moderate negative relationship between perceived difficulty and dead-hang performance indicating that as endurance improved, exercises felt progressively less challenging despite maintaining consistent effort levels.

2) Plateau Observations and Breakthrough Patterns: Analysis of the data revealed several plateau periods, particularly:

- 4-repetition plateau (Days 28-47): Extended period of performance stabilization lasting approximately 20 days
- Breakthrough to 5 repetitions (Day 48): Coincided with lat spread width increase to 45 cm
- Peak performance of 6 repetitions (Day 58): Achieved after further body composition improvements

Training notes documented that laughter and distraction occasionally impacted performance, with performance dips observed on days with noted psychological factors. However, the overall trend remained positive, suggesting strong underlying physiological adaptation.

F. Discussion

The results provide compelling evidence for the efficacy of progressive dead-hang training as a foundation for pull-up development over an extended 9-week period. The strong positive correlation ($r = 0.762$) between dead-hang duration and pull-up capability, maintained across 61 training sessions, suggests that grip strength and shoulder stabilization are fundamental prerequisites for sustained pull-up performance.

The significant improvements in body composition metrics align with the biomechanical demands of dead-hang and pull-up exercises. The lat spread width increase of 4.5% (+2.0 cm) represents meaningful muscle hypertrophy and correlates with the strongest association to pull-up performance. Similarly, forearm circumference gains of 7.7-8.0% (+2.0 cm bilaterally) reflect substantial grip strength development essential for dead-hang endurance.

The achievement of 6 maximum pull-ups by week 9 demonstrates that continued training beyond initial breakthrough yields progressive adaptations. The 37.6% reduction in perceived difficulty despite increasing absolute performance indicates improved movement economy and neural efficiency—key markers of training adaptation.

Body weight stability (0% change) throughout the training period is particularly noteworthy. This finding suggests that for individuals within normal weight ranges, relative strength gains through neuromuscular adaptation and muscle quality enhancement are more important than body weight manipulation for pull-up progression. The participant achieved a 600% increase in pull-up capacity (0 to 6 repetitions) without any changes in body mass, emphasizing the primacy of strength development over weight loss strategies.

The documented variability in daily performance (Coefficient of variation = 18.6%) reflects normal physiological fluctuations influenced by fatigue, recovery status, and psychological factors. The typical variability is $\pm$ 12.87 seconds represented by CV=18.6%. Participant notes documented instances where external factors such as laughter affected performance, highlighting the importance of mental focus during maximal effort attempts. However, the consistent long-term trend validates the robustness of the training approach despite day-to-day variations.

V. Conclusion

A. Key Findings

This 9-week longitudinal self-tracking study systematically examined the relationship between daily dead-hang training and pull-up performance development, yielding several significant findings. First, the study demonstrates that progressive dead-hang training produces statistically significant improvements in pull-up capacity, with the participant progressing from 0 to 6 maximum repetitions over 61 training sessions ($p < 0.05$). The strong positive correlation between dead-hang duration and pull-up performance ($r = 0.751$, $p = 3.09 \times 10^{-12}$) validates grip endurance as a fundamental prerequisite for vertical pulling strength.

Second, body composition analysis revealed that upper body muscle development, particularly forearm and biceps hypertrophy, exhibited highly significant associations with pull-up performance improvements. Left forearm circumference demonstrated the strongest correlation ($r = 0.7663$, $p = 6.16 \times 10^{-13}$), followed by left biceps ($r = 0.7272$, $p = 3.22 \times 10^{-11}$), indicating that grip strength serves as the primary limiting factor during beginner-to-intermediate training phases. Bilateral muscle development showed consistent 7-8% increases in forearm and biceps circumference (+2.0 cm), alongside 4.5% lat spread width growth, representing physiologically significant hypertrophy achieved through compound bodyweight training.

Third, the study established that performance improvements occurred independently of body weight manipulation. The participant achieved a 600% increase in pull-up capacity while maintaining stable body weight (61.0 kg throughout, CV = 0.8%), demonstrating that relative strength gains through neuromuscular adaptation supersede body mass reduction as the primary mechanism for pull-up progression in normal-weight individuals. Additionally, perceived difficulty decreased by 37.6% from early (8.5/10) to late training phases (5.3/10), providing quantitative evidence of enhanced training economy and neuromuscular efficiency despite progressively increasing absolute performance demands.

B. Personal Insights and Self-Discovery

Through systematic self-tracking and data analysis, several meaningful personal insights emerged regarding my physical capabilities, adaptation patterns, and behavioral tendencies. The 18-day period required to achieve the first successful pull-up revealed that initial strength development follows a latent adaptation phase wherein foundational capacity builds before functional performance manifests. This finding challenged my initial expectations of linear progression and taught patience in skill acquisition—recognizing that invisible adaptations precede visible results.

The discovery of left-side dominance in correlation strength (left forearm and biceps showing strongest performance associations) provided unexpected insight into asymmetric strength development patterns. This finding suggests either genuine neuromuscular imbalance or potential measurement reliability considerations, highlighting the importance of bilateral training attention to prevent long-term imbalances. The documentation of performance variability (CV = 18.6%, $\pm$12.87 seconds typical fluctuation) normalized day-to-day performance inconsistencies that previously caused frustration. The left side's dominance in correlation strength means that the left side is inferior to the dominant right side, and now is able to catch up in terms of muscle growth, because of repeated push to the muscle towards pullups.

The negative correlation between perceived difficulty and objective performance ($r = -0.83$) revealed a profound disconnect between subjective effort perception and actual capacity development. As physical capability increased substantially, exercises felt progressively easier—demonstrating that neuromuscular efficiency improvements occur alongside strength gains. This insight emphasizes that relying solely on effort perception can underestimate actual progress, validating the importance of objective performance tracking for accurate self-assessment.

Perhaps most importantly, the body weight stability finding (0% change despite 600% performance improvement) challenged deeply ingrained assumptions that weight loss is necessary for pull-up progression as well as that the fluctuations of body weight has no connection to the progression of pull-ups. This discovery shifted my training philosophy from body mass manipulation toward strength quality optimization, demonstrating that muscle remodeling and neuromuscular efficiency drive functional capacity more effectively than caloric restriction in normal-weight individuals.

C. Real-Life Applications and Practical Implications

The findings from this study translate into several actionable principles applicable beyond the specific context of pull-up training. First, the validation of progressive dead-hang training as an effective preparatory exercise establishes a practical training protocol for individuals unable to perform pull-ups initially. The recommended approach involves daily dead-hang practice with gradual duration increases (average improvement rate: 0.468 seconds/day), which develops grip strength, shoulder stabilization, and neuromuscular coordination prerequisite for pull-up execution. This method provides an accessible entry point for beginners without requiring specialized equipment beyond a standard pull-up bar.

Second, the body composition findings suggest that training program design should prioritize grip strength development during early progression phases. Since forearm circumference demonstrated stronger performance associations ($r = 0.77$) than latissimus dorsi development ($r = 0.59$), supplementary grip-specific exercises (farmer's walks, plate pinches, towel hangs) may accelerate initial pull-up capability more effectively than traditional back-dominant exercises like lat pulldowns. This hierarchical limitation model informs periodization strategies wherein grip-specific interventions receive emphasis before transitioning to back-dominant exercises at advanced performance levels.

Third, the weight stability finding challenges conventional fitness advice that emphasizes caloric restriction for pull-up progression. For individuals within normal weight ranges (BMI 18.5-24.9), training protocols should focus on strength development and muscle quality enhancement rather than weight loss strategies. This paradigm shift prevents potentially counterproductive caloric restriction that may impair recovery and hypertrophy while emphasizing progressive overload and adequate nutritional support for adaptation.

Finally, the documentation of performance variability (CV = 18.6%) provides realistic expectations for training consistency. Understanding that daily fluctuations of ± 12.87 seconds represent normal physiological variation rather than training failure reduces psychological stress associated with inconsistent performance. This insight encourages focus on longitudinal trends rather than session-to-session comparisons, promoting adherence by normalizing natural variability inherent in human performance.

D. Final Conclusion

This comprehensive self-tracking study successfully demonstrates that systematic dead-hang training produces statistically significant improvements in pull-up performance through coordinated development of grip strength, upper body muscle mass, and neuromuscular efficiency. The rejection of both null hypotheses—confirming that (1) dead-hang training improves pull-up capability ($r = 0.751$, $p < 0.05$) and (2) body composition changes associated with performance improvements ($r = 0.59$-0.77, $p < 0.05$)—provides robust evidence supporting progressive bodyweight training methodologies for strength development in previously untrained individuals.

The achievement of 6 maximum pull-ups across 61 training sessions, representing a 600% performance increase without body weight manipulation, validates relative strength development as the primary mechanism for functional capacity enhancement. The strong correlations between forearm/biceps hypertrophy and pull-up performance ($r = 0.67$-0.77) establish grip strength as the primary limiting factor during beginner-to-intermediate training phases, with practical implications for exercise selection and periodization strategies in early strength development programs.

Beyond the specific context of pull-up training, this study exemplifies the value of rigorous self-experimentation and quantitative behavior tracking for understanding personal adaptation patterns. The integration of performance metrics, anthropometric measurements, and subjective difficulty ratings provided multidimensional insight unattainable through isolated measurement approaches. The documentation of normal performance variability (CV = 18.6%), adaptation timelines (18 days to first pull-up), and efficiency improvements (37.6% perceived difficulty reduction) established realistic expectations that normalize the non-linear nature of skill acquisition and strength development.

The methodological approach employed—systematic daily data collection, longitudinal tracking, statistical hypothesis testing, and correlation analysis—demonstrates that principles of scientific inquiry can be applied to personal behavior change with meaningful results. This self-directed research process not only answered specific questions about pull-up training efficacy but also developed critical analytical skills in data management, statistical interpretation, and evidence-based decision-making applicable across diverse domains of personal development.

In conclusion, this study confirms that progressive dead-hang training represents an effective, accessible, and evidence-based approach to developing pull-up capacity in individuals beginning from zero baseline performance. The findings challenge conventional assumptions about the necessity of weight loss for pull-up progression while validating the importance of grip strength development, bilateral muscle hypertrophy, and neuromuscular adaptation as primary drivers of functional pulling strength. These insights contribute to the broader understanding of bodyweight training principles and provide actionable guidance for individuals seeking to develop upper-body pulling performance through self-directed training protocols.

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