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Arm muscle power, eye-hand coordination, and psychological distress predict jab-straight punch frequency

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Abstract

Jab-straight punch frequency is an important indicator of repeated punching performance in boxing and may be associated with physical, coordinative, and psychological characteristics. This study examined associations between arm muscle power, eye-hand coordination, and GHQ-12 psychological distress scores and jab-straight punch frequency among boxing athletes registered under PERTINA Gorontalo Province. A quantitative cross-sectional correlational design with multiple linear regression analysis was used. All 15 eligible athletes were included through total sampling; therefore, the findings apply only to this study sample. Arm muscle power, eye-hand coordination, and psychological distress scores were assessed using the Seated Medicine Ball Throw, Wall Toss Test, and General Health Questionnaire-12, respectively. Jab-straight punch frequency was defined as the number of valid punches completed within 30 seconds. The regression model was statistically significant, $F(3, 11) = 108.799$, $p < .001$, $R^2 = .967$, and adjusted $R^2 = .959$. Eye-hand coordination showed a positive regression coefficient ($B = 1.616$, $p < .001$), whereas arm muscle power ($B = -3.155$, $p = .043$) and psychological distress scores ($B = -0.216$, $p < .001$) showed negative coefficients. Higher psychological distress scores were associated with lower jab-straight punch frequency. These findings may provide preliminary information for evaluating the measured variables within this sample. Future studies with larger, more diverse samples and specific biomechanical tools are needed to further examine these associations.

Keywords: Jab-straight punch frequency, arm muscle power, eye-hand coordination, psychological distress, boxing athletes

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Authors contribution: a – Preparing concepts; b – Formulating methods; c – Conducting research; d – Processing results; e – Interpretation and conclusions; f - Editing the final version.

INTRODUCTION

Jab-straight punches are fundamental offensive techniques in boxing because they are commonly used to initiate attacks, create space, control

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distance, disrupt an opponent's rhythm, and score points during competition. Effective attacks are reflected not only in the ability to land punches on the target but also in the athlete's capacity to maintain technical efficiency while executing offensive actions quickly, accurately, and repeatedly under competitive pressure. Straight-punch performance can be examined through several distinct indicators, including punch velocity, impact force, accuracy, and repeated punch frequency. Previous studies have identified strike velocity and impact force as relevant biomechanical indicators of combat-sport performance (Beránek et al., 2023). Dunn et al. (2022) reported that upper- and lower-body strength and power were associated with punch impact force, while Lopez-Laval et al. (2020) found that bench-press strength and movement velocity were related to punching performance in professional boxers. A validated smart-wearable system has also been used to characterize boxing-punch execution through strike trajectory, force, velocity, and punch time and to compare technical performance between experienced and non-experienced participants (Menzel & Potthast, 2021). These biomechanical indicators differ from the outcome examined in the present study. Therefore, jab-straight punch frequency was operationalized as the number of valid jab-straight punches completed within 30 seconds and was used to represent repeated punching performance rather than single-punch biomechanical velocity or impact force.

Previous research using a real-time feedback-based model showed that straight-punch movement patterns could be assessed through structured and measurable procedures (Khasanshin & Osipov, 2021). This study is cited only to illustrate the use of boxing-specific technical assessment. It should not be interpreted as evidence that the present study demonstrates improved punching performance. Auditory biofeedback based on bag acceleration has also been examined as a method for evaluating boxing-jab performance and technique, with technical responses differing between novice and experienced participants (Chen et al., 2021). These findings support the relevance of

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boxing-specific performance assessment while remaining conceptually distinct from the count-based jab-straight punch frequency examined in the present study.

Arm muscle power may be associated with jab-straight punch frequency because straight-punch execution requires explosive force production and coordinated movement across the lower limbs, trunk, shoulders, and upper limbs (Zawawi & Firdaus, 2021). Effective punching actions are not determined by upper-limb power alone because force must be transferred efficiently through the kinetic chain. During a jab-straight punch, arm muscle power contributes to explosive upper-limb movement, while the quality of punch execution depends on coordinated whole-body movement. Biomechanical comparisons between elite and junior boxers have demonstrated differences in punch velocity, peak force, relative strength, impulse, rate of force development, and lead-leg force-production characteristics during the lead straight punch (Liu et al., 2022). Parry et al. (2021) also reported that push-up countermovement parameters provide reliable indicators of upper-extremity power in elite boxers. Accordingly, arm muscle power should be understood as one biomotor predictor that may be associated with jab-straight punch frequency when supported by efficient force transfer across the lower limbs, trunk, shoulders, and upper limbs.

Eye-hand coordination may support repeated punching performance through timing accuracy, visual response, target identification, and movement regulation. During a jab-straight punch, athletes must recognize the target, estimate distance, control movement direction, respond to visual information, and coordinate upper-limb movement rapidly and accurately. Evidence from perceptual and visual-motor studies indicates that reaction time, anticipation, and eye-hand coordination are relevant to boxing-related performance. A systematic review and meta-analysis showed that expert combat-sport athletes generally demonstrate faster reaction times and greater response accuracy than non-experts during perceptual-anticipation tasks (Zhang et al., 2022).

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Boxing-specific virtual-reality research has also shown that viewing conditions may influence fixation duration, head movement, and perceived presence during anticipatory tasks (Loiseau Taupin et al., 2023). Wu et al. (2024) reported that reaction time, eye-hand coordination, and depth perception were associated with competitive punching outcomes in amateur boxers, while Mahlangu et al. (2024) emphasized that eye-hand coordination and movement speed are important visual skills supporting rapid responses, anticipation, and efficient technical execution in boxing. However, the performance indicators used in these studies may differ from the outcome examined in the present study. Perceptual anticipation and punching accuracy are conceptually related to, but not equivalent to, the Wall Toss Test or jab-straight punch frequency measured over 30 seconds. Therefore, eye-hand coordination is treated as a visual-motor predictor that may be associated with repeated jab-straight punching performance rather than as a direct measure of punch frequency.

Psychological distress may also be associated with technical execution in boxing because athletes are required to maintain concentration, emotional regulation, self-control, and rapid decision-making during dynamic offensive and defensive situations. Anxiety, stress, competitive pressure, and reduced concentration may be related to unstable movement timing, slower reactions, decreased movement control, and less consistent technical execution during repeated punching actions. Previous studies have examined cognitive anxiety, somatic anxiety, concentration, self-confidence, psychological distress, depression, and performance-related pressure among athletes, although these studies did not directly assess boxing-specific punch frequency (Trpkovici et al., 2023; Beauchamp et al., 2021; Reardon, 2023; Tubić et al., 2022). These constructs should not be treated as equivalent to the operational variable measured in the present study. Psychological distress was assessed using the General Health Questionnaire-12 (GHQ-12), with higher scores indicating greater psychological distress. The GHQ-12 provides an indicator of general

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psychological distress and should not be interpreted as a clinical diagnosis. Accordingly, psychological distress scores may be associated with jab-straight punch frequency through their potential relationships with concentration, movement timing, reaction speed, movement control, and consistency during repeated punching performance. Psychological functioning should also be understood within the context of athletic performance rather than solely as an indicator of general well-being (Afifah Dwi Pramesti & Faizah, 2022).

Previous studies on boxing performance have generally examined three areas separately. The first group has focused on biomotor factors, including arm muscle power, upper-body strength, punch velocity, and impact force. The second group has examined visual-motor factors, including reaction time, anticipation, visual ability, and eye-hand coordination. The third group has investigated psychological distress, athlete well-being, mental support, and performance-related pressure. However, limited evidence exists on the simultaneous associations of arm muscle power, eye-hand coordination, and psychological distress scores with jab-straight punch frequency within a single multiple linear regression model. This gap indicates the need for an integrated analysis of biomotor, visual-motor, and psychological predictors of repeated punching performance.

This study therefore aimed to examine the individual and joint associations of arm muscle power, eye-hand coordination, and psychological distress scores with jab-straight punch frequency among boxing athletes registered under PERTINA Gorontalo Province. The study's scientific contribution is to provide initial empirical information on these three predictors within a single analytical framework. From a practical perspective, the findings may provide preliminary information for athlete evaluation but should not be interpreted as a direct basis for designing or prescribing boxing training programs.

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METHOD

Research Design and Participants

This study employed a quantitative cross-sectional correlational design to examine the individual and joint predictive associations of arm muscle power, eye-hand coordination, and psychological distress scores with jab-straight punch frequency among boxing athletes in Gorontalo Province. Data were collected at a single time point without experimental treatment. Jab-straight punch frequency was defined as the number of valid jab-straight punches completed within 30 seconds rather than single-punch biomechanical velocity. Multiple linear regression was conducted after evaluating the required assumptions, and the findings were interpreted cautiously because of the limited sample size.

Data collection was conducted in May 2025 at the Gorontalo Province boxing athlete training center at Universitas Negeri Gorontalo. All 15 eligible athletes registered with PERTINA Gorontalo Province were included through total sampling. The participants comprised nine male athletes in the 48–63 kg weight classes and six female athletes in the 57–63 kg weight classes. They were 19–23 years old, had one to two years of boxing experience, trained three times per week, and had competed at regional, provincial, or national levels.

Eligibility and Ethical Considerations

The inclusion criteria were active registration with PERTINA Gorontalo Province, regular participation in boxing training, physical fitness during testing, willingness to participate, and completion of all measurement procedures. Athletes were excluded if they had shoulder, arm, wrist, or hand injuries; were ill during data collection; had health conditions that could affect test performance; or did not complete the full test battery.

Formal ethics committee approval was not required under the applicable institutional regulations. Permission was obtained from PERTINA Gorontalo

Province. All participants received information about the study's purpose, procedures, potential benefits, and possible risks before providing written informed consent. Participation was voluntary, confidentiality was maintained, and participants could withdraw at any time without consequences.

Testing Conditions and Data Collection Procedures

All measurements were conducted at the same training facility under comparable environmental conditions. Participants were instructed to avoid strenuous physical activity for at least 24 hours before testing and to maintain their usual hydration and dietary routines. Before the physical measurements, they rested for 10 minutes. They completed a standardized 10–15-minute warm-up consisting of light jogging, dynamic stretching, mobility exercises, shadow boxing, basic footwork, and light jab-straight combinations.

Measurements were conducted in the following order: GHQ-12, Wall Toss Test, Seated Medicine Ball Throw, and the 30-second jab-straight punch frequency test. The GHQ-12 was administered first because it involved no physical exertion. The Wall Toss Test preceded the power and repeated-punching tests to minimize fatigue effects on eye-hand coordination. The jab-straight punch frequency test followed the Seated Medicine Ball Throw as the most physically demanding measurement. A rest interval of three to five minutes was provided between test types.

Measurement Instruments

Arm muscle power was assessed using the Seated Medicine Ball Throw test. Each athlete sat with the back and shoulders against a wall, legs extended, and a 3-kg medicine ball held at chest level. The ball was pushed forward using a two-handed chest-pass movement while maintaining the seated position. Three trials were completed with a 60-second rest interval, and the longest throwing distance was used for analysis.

Eye-hand coordination was assessed using the Wall Toss Test. Each athlete stood approximately 2 m from a marked wall target and alternately threw

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and caught a tennis ball with opposite hands for 30 seconds. One point was awarded for each successful sequence, while failed catches, dropped balls, and throws outside the target area were not counted. Participants completed two trials with a 60-second rest interval, and the highest score was analyzed.

Psychological distress was assessed using the Indonesian version of the General Health Questionnaire-12. The instrument consists of 12 items scored from 0 to 3, producing a total score of 0–36. Higher scores indicate greater psychological distress, and the total score was used in the regression analysis.

Jab-straight punch frequency was assessed as the number of valid jab-straight punches completed against a heavy bag within 30 seconds. Testing began after the commands “ready” and “start” and ended at the stop signal. A punch was valid when it followed the correct sequence, made clear contact, demonstrated sufficient arm extension, and was performed with controlled posture. Missed, incomplete, incorrectly sequenced, or late punches were not counted. Two trained recorders were involved: one counted valid punches, while the other monitored technical execution and controlled timing.

Validity and Reliability

The Seated Medicine Ball Throw has demonstrated high test–retest reliability, with ICC values ranging from .95 to .98. The Wall Toss Test has shown acceptable validity and reliability, including validity of approximately $r = .85$ and ICC values ranging from .85 to .93. Indonesian GHQ-12 validation studies have reported Cronbach’s alpha values ranging from .76 to .86. Previous boxing-specific continuous punching procedures have also supported the applicability of repeated punching assessments. No additional validity or reliability testing was conducted in the present sample; therefore, the study relied on published psychometric evidence and standardized administration and scoring procedures.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 25. Descriptive statistics included the mean, standard deviation, minimum, maximum, and range. Regression assumptions included normality, linearity, multicollinearity, heteroscedasticity, and residual independence. Normality was assessed using the Shapiro–Wilk test, linearity using deviation-from-linearity values, multicollinearity using tolerance and variance inflation factor values, heteroscedasticity through visual inspection of the standardized residual scatterplot, and residual independence using the Durbin–Watson statistic. Multiple linear regression examined the individual and joint predictive associations of the three predictor variables with jab-straight punch frequency. Individual coefficients were evaluated using t-statistics, while the overall model was evaluated using the F statistic. R^2 and adjusted R^2 described the proportion of outcome variance explained by the predictors. The significance level was set at $p < .05$.

RESULTS

The Results are organized into five subsections: descriptive statistics, assumption testing, model summary, and regression coefficients. Descriptive statistics for arm muscle power, eye-hand coordination, psychological distress scores, and jab-straight punch frequency are presented in Table 1.

Table 1. Descriptive Statistics of The Study Variables

Variable	N	Mean	Standard Deviation
Arm muscle power (X1)	15	5.467	1.038
Eye-hand coordination (X2)	15	29.40	3.996
Psychological distress scores (X3)	15	21.67	4.731
Jab-straight punch frequency (Y)	15	77.53	9.978

The descriptive statistics showed that the mean arm muscle power score was 5.467 with a standard deviation of 1.038. Eye-hand coordination had a mean score of 29.40 with a standard deviation of 3.996. Psychological distress scores had a mean of 21.67 with a standard deviation of 4.731, while jab-straight punch frequency had a mean of 77.53 with a standard deviation of

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9.978. These results provide a general description of the arm muscle power, eye-hand coordination, psychological distress scores, and jab-straight punch frequency of the 15 athletes included in the study.

Table 2. Normality Test

Variable	N	Shapiro-Wilk Statistic	p-value
Arm muscle power (X1)	15	0.964	0.754
Eye-hand coordination (X2)	15	0.932	0.288
Psychological distress scores (X3)	15	0.908	0.126
Jab-straight punch frequency (Y)	15	0.975	0.924

Before hypothesis testing, several assumption tests were performed to ensure the data met the requirements for regression analysis. These tests included normality, linearity, multicollinearity, heteroscedasticity, and autocorrelation. The Shapiro-Wilk test indicated that the significance values for all variables exceeded the 0.05 threshold, with X1 = 0.754, X2 = 0.288, X3 = 0.126, and Y = 0.924. Therefore, the data for all variables can be considered normally distributed.

Table 3. Linearity Test

No	Variables	Sig. Linearity	Deviation from Linearity
1	$Y * X_1$	.029	.627
2	$Y * X_2$	.018	.963
3	$Y * X_3$	.026	.265

The linearity assumption was evaluated using the Deviation from Linearity value. The results showed that the Deviation from Linearity values for Y with X1, X2, and X3 were 0.627, 0.963, and 0.265, respectively. Since all values were greater than 0.05, the relationships between each predictor and jab-straight punch frequency were considered linear. Therefore, the linearity assumption for regression analysis was fulfilled. The linearity test showed that the association between Y and X1 had a Sig. Linearity value of 0.029 with a Deviation from Linearity value of 0.627. The association between Y and X2 produced a Sig. Linearity value of 0.018 and a Deviation from Linearity value of 0.963.

Meanwhile, the association between Y and X3 showed a Sig. Linearity value of 0.026 and a Deviation from Linearity value of 0.265. Since the Deviation from Linearity values were greater than 0.05, the data indicate a linear pattern between each predictor and jab-straight punch frequency.

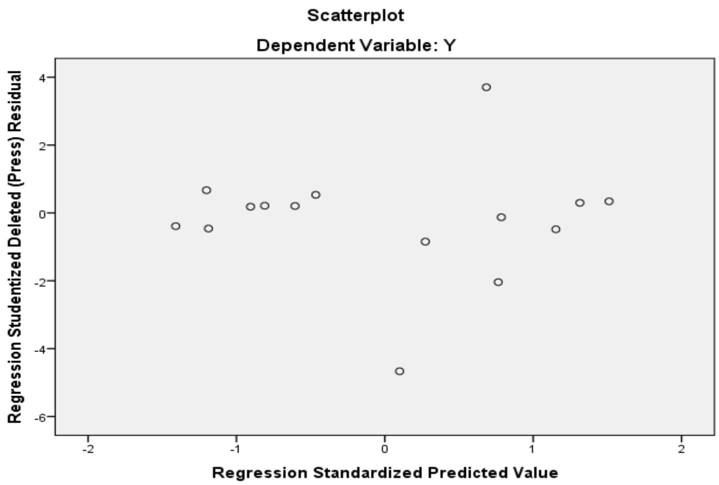

Figure 1. Scatterplot

Figure 1 presents the residual scatterplot. Visual inspection of the residual scatterplot showed that the residual points were randomly dispersed and did not form a distinct systematic or funnel-shaped pattern. Based on this graphical assessment, there was no obvious indication of heteroscedasticity in the regression model; however, this conclusion should be interpreted cautiously because it was derived from visual inspection rather than a formal statistical test. The Durbin–Watson value of 1.931 was reported only as a complementary diagnostic for residual independence because this study used cross-sectional data rather than time-series data.

Model Summary

Table 4 presents the summary of the multiple linear regression model. The model produced an R value of .984, with $R^2 = .967$ and adjusted $R^2 = .959$. Because the model included three predictor variables and the sample size was limited, adjusted R^2 was considered the primary indicator of explained variance. The adjusted R^2 value indicated that approximately 95.9% of the variance in

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jab-straight punch frequency was explained by the regression model. The Standard Error of the Estimate was 2.032, indicating the model's average prediction error. The Durbin–Watson statistic was 1.931, which was close to 2 and therefore did not indicate substantial residual autocorrelation. Because the study used cross-sectional data, the Durbin–Watson statistic was interpreted only as a complementary indicator of residual independence. Given the relatively small sample size (n = 15), these regression estimates should be interpreted cautiously.

Table 4. Model Summary

Model	R	R Square	Adjusted R Square	Standard Error of the Estimate	Durbin-Watson
1	.984 [a]	.967	.959	2,032	1,931

a. Predictors: (Constant), X3, X2, X1
b. Dependent Variable: Y

ANOVA Test

The ANOVA test showed that the overall regression model was statistically significant, $F(3, 11) = 108.799$, $p < .001$. This result indicates that arm muscle power, eye-hand coordination, and psychological distress scores were simultaneously associated with jab-straight punch frequency.

Table 5. ANOVA Test Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1348.294	3	449.431	108.799	<.001 [b]
	Residual	45.439	11	4.131		
	Total	1393.733	14			

a. Dependent Variable: Y
b. Predictors: (Constant), X3, X2, X1

Regression Coefficients

The regression coefficient results showed that arm muscle power was a significant predictor of jab-straight punch frequency with a negative regression coefficient ($B = -3.155$, $t = -2.286$, $p = .043$). Eye-hand coordination was a significant predictor with a positive regression coefficient ($B = 1.616$, $t = 5.693$, $p < .001$). Psychological distress scores were also a significant predictor with a negative regression coefficient ($B = -0.216$, $t = -6.974$, $p < .001$). Since the GHQ-12 score reflects psychological distress, the negative coefficient indicates that higher psychological distress scores were associated with lower jab-straight punch frequency.

Table 6. Multicollinearity Statistics

Predictor	Tolerance	VIF
Arm muscle power (X_1)	.144	6.961
Eye-hand coordination (X_2)	.229	4.361
Psychological distress scores (X_3)	.277	3.605

Table 7 presents the multicollinearity diagnostics. All tolerance values exceeded 0.10, and all variance inflation factor (VIF) values were below 10, indicating no serious multicollinearity among the predictor variables. However, the VIF value for arm muscle power was relatively higher than those of the other predictors, suggesting potential moderate multicollinearity that should be considered when interpreting the regression coefficients.

Table 7. Multiple Linear Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	73.573	9,406		7.822	< .001
	X1	-3.155	1.380	-.328	-2.286	0.043
	X2	1.616	0.284	.647	5.693	< .001
	X3	-0.216	0.031	-.721	-6.974	< .001

Based on the unstandardized coefficient values, the regression equation can be written as follows: $Y = 73.573 - 3.155X_1 + 1.616X_2 - 0.216X_3$. In this equation, Y represents jab-straight punch frequency, X_1 represents arm muscle power, X_2 represents eye-hand coordination, and X_3 represents psychological distress scores. Each coefficient indicates the expected change in the predicted value of Y for each one-unit increase in the predictor, while the other predictors are statistically controlled. Specifically, each one-unit increase in arm muscle power was associated with a 3.155-unit decrease in the predicted jab-straight punch frequency, each one-unit increase in eye-hand coordination was associated with a 1.616-unit increase in the predicted jab-straight punch frequency, and each one-unit increase in psychological distress score was associated with a 0.216-unit decrease in the predicted jab-straight punch frequency, assuming the other predictors remained constant.

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DISCUSSION

Jab-straight punch frequency should be understood as a multidimensional performance indicator associated with arm muscle power, eye-hand coordination, and psychological distress scores. The regression model showed that these three predictor variables were jointly associated with jab-straight punch frequency within this sample of boxing athletes. These findings indicate that repeated jab-straight punching performance was related not only to arm muscle power but also to eye-hand coordination and psychological distress scores. Wu et al. (2024) similarly reported that visual abilities, including eye-hand coordination, reaction time, and depth perception, were associated with punching outcomes among amateur boxers. However, the indicators used in that study may differ from the outcome examined here, which was defined as the number of valid jab-straight punches completed within 30 seconds. Accordingly, jab-straight punch frequency should be interpreted as a boxing-specific outcome associated with several measured variables rather than one dominant factor.

Arm muscle power showed a significant negative regression coefficient with jab-straight punch frequency. This finding should be interpreted cautiously because the outcome represented repeated punch frequency over 30 seconds rather than single-punch biomechanical velocity or impact force. Previous experimental research evaluated rear-hand straight-punch performance using punch force and punch velocity following ballistic and heavy-resistance conditioning exercises (Yi et al., 2022). Biomechanical studies have also examined peak punch velocity, impulse, peak force, rate of force development, and lower-limb force production during straight-punch execution (Liu et al., 2023). These outcomes differ conceptually from the count-based measure used in the present study. The negative association may therefore reflect the specific outcome measured, the small sample size, potential moderate collinearity among predictors, and the distinction between maximal upper-body power and the ability to sustain rapid repeated punching. Athletes with greater arm muscle power may not necessarily complete more valid punches if movement rhythm, technical efficiency, coordination, and repetition control are not maintained. Wilson et al. (2020) likewise emphasized the contribution of muscular strength to punch impact force, although punch impact force and repeated punch frequency represent different performance characteristics. The negative coefficient should therefore be regarded as an empirical finding specific to this repeated punching task and requires further examination using larger samples and more comprehensive biomechanical measurements.

Eye-hand coordination showed a positive and significant association with jab-straight punch frequency. This finding indicates that visual-motor ability was related to repeated punching performance during the 30-second test. Still, it should not be interpreted as direct evidence of improved punching accuracy because accuracy was not measured. Better eye-hand coordination may support the regulation of punch timing, target orientation, movement continuity, and rapid motor responses during repeated punching actions. Previous research has shown that eye-hand coordination, reaction time, and depth perception are associated with boxing performance (Wu et al., 2024). Mahlangu et al. (2024) also reported superior visual-spatial abilities among amateur boxers compared with non-athletes, indicating the relevance of visual-motor abilities to boxing-specific performance. Nevertheless, because previous investigations used different performance indicators, the present result should be interpreted specifically in relation to repeated jab-straight punch frequency measured over 30 seconds.

Psychological distress scores were also significantly associated with jab-straight punch frequency, with a negative regression coefficient. Because higher GHQ-12 scores indicate greater psychological distress, athletes with higher psychological distress scores tended to achieve lower jab-straight punch frequency. Possible mechanisms include reduced attentional focus, emotional regulation, movement consistency, self-control, and technical execution during

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repeated punching tasks. However, these mechanisms were not directly measured and should therefore be considered tentative rather than confirmed explanations. Ekelund et al. (2025) emphasized the importance of psychological functioning in understanding athletes' performance-related functioning under competitive conditions. Evidence regarding mindfulness-based interventions remains mixed. Myall et al. (2023) reported improvements in anxiety, stress, and psychological well-being among elite athletes. In contrast, Xie et al. (2025) found improvements in mindfulness-related outcomes but no consistent effect on broader mental health outcomes. These intervention findings should not be interpreted as evidence that reducing psychological distress would necessarily increase jab-straight punch frequency; instead, they provide broader contextual support for the relevance of psychological functioning in sport.

The novelty of this study lies in examining arm muscle power, eye-hand coordination, and psychological distress scores simultaneously within a single multiple linear regression model. The findings provide preliminary evidence that these three predictor variables were jointly associated with jab-straight punch frequency among the regional boxing athletes studied. Cui et al. (2024) is cited only as conceptual support for the importance of using boxing-specific performance assessments. Because that study evaluated a training intervention, it should not be interpreted as evidence that arm muscle power, eye-hand coordination, or psychological distress scores directly improve jab-straight punch frequency in the present correlational study. The findings should therefore be interpreted as preliminary evidence applicable only to the athletes included in this sample.

The practical implication of this study is limited to providing preliminary information for athlete evaluation. Arm muscle power, eye-hand coordination, and psychological distress scores may be considered as factors associated with jab-straight punch frequency among athletes registered under PERTINA

Gorontalo Province. However, the findings should not be used as a direct basis for designing or modifying training programs because the study employed a cross-sectional correlational design and involved only 15 regional boxing athletes.

Several limitations should be considered. First, the cross-sectional design does not permit causal conclusions regarding the associations between the predictor variables and jab-straight punch frequency. Second, the small sample size may limit the stability and generalizability of the regression model. Third, the outcome represented repeated punch frequency rather than single-punch biomechanical velocity or impact force. Fourth, the relatively high variance inflation factor for arm muscle power indicated potential moderate collinearity that should be considered when interpreting the regression coefficients. Finally, punching technique, fatigue, movement rhythm, and technical efficiency were not directly measured. Future studies should use larger, more diverse samples and validated boxing-specific monitoring systems, including motion-analysis devices, punch sensors, accelerometers, force-measurement systems, or instrumented punching bags, to more accurately distinguish jab-straight punch frequency, punch velocity, punch impact force, and other biomechanical characteristics.

CONCLUSION

Among the PERTINA Gorontalo Province boxing athletes studied, arm muscle power, eye-hand coordination, and GHQ-12 psychological distress scores were significantly associated with jab-straight punch frequency, both individually and jointly within the regression model. Eye-hand coordination showed a positive association, whereas arm muscle power and psychological distress scores showed negative associations with jab-straight punch frequency. The study outcome represented repeated jab-straight punch frequency over 30 seconds rather than single-punch biomechanical velocity. These findings may provide preliminary information for evaluating the

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measured variables in athlete performance assessment but should not be used as a direct basis for designing training programs. Given the cross-sectional correlational design and relatively small sample, interpret the findings cautiously and limit them to the athletes included in this study. Future studies should involve larger and more diverse samples and use biomechanical tools capable of distinguishing punch frequency, punch velocity, and punch impact force more precisely.

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