



(RESEARCH ARTICLE)



THE RELATIONSHIP BETWEEN INDEX OVERALL DEMAND AND PHYSICAL PERFORMANCE WITH DEFENSIVE SKILLS OF THE PBV HANS SURABAYA WOMEN'S VOLLEYBALL TEAM

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ABSTRACT

This study aimed to examine the relationships between Index Overall Demand (IOD), physical performance, and defensive dig skills among female volleyball players at PBV Hans Surabaya. A quantitative correlational study with an ex post facto design was conducted involving 30 athletes aged 11–16 years selected through purposive sampling. Data were collected through training-load monitoring, physical performance tests, and defensive skill assessments. Pearson or Spearman correlation and multiple linear regression were used for data analysis, with a significance level of 0.05. The results showed that IOD ($r = 0.197$; $p = 0.271$), $VO_{2\max}$ ($r = 0.133$; $p = 0.460$), and vertical jump ($r = 0.267$; $p = 0.133$) were not significantly associated with defensive dig skills. However, hand grip strength showed a significant positive relationship ($r = 0.511$; $p = 0.002$) and was the only significant individual predictor ($p = 0.009$). Simultaneously, IOD and physical performance were significantly associated with defensive dig skills ($F = 3.591$; $p = 0.017$), explaining 33.9% of the variance ($R^2 = 0.339$). These findings highlight the potential relevance of hand grip strength and the need to integrate physical conditioning with sport-specific defensive training.

Keywords: Index Overall Demand, Physical Performance, Hand Grip Strength, Defensive Dig, Volleyball

1. INTRODUCTION

Volleyball is a popular sport enjoyed by people of various age groups, from children to adults. The game is generally played by six players on each team, although the number of players can be adjusted according to the format of the game [1]. Volleyball can be played on various surfaces, including sand, wood, grass, and artificial flooring, both indoors and outdoors [2–5]. As a team sport, volleyball requires players to cooperate and support one another to develop effective teamwork [6]. Therefore, individual mastery of fundamental volleyball techniques is essential for building a cohesive

and competitive team [7]. These techniques include the forearm pass, overhead pass, smash, underhand serve, overhand serve, and block [8–10].

The women's volleyball team of PBV Hans Surabaya is an active club that participates in competitions across Surabaya and surrounding areas, including regional, municipal, provincial, and beach volleyball championships. As the team continues to develop, coaches and club management require objective information to evaluate training quality and athletes' performance during competitions. One essential technical skill in volleyball is defensive performance, particularly the dig, which involves receiving and controlling the opponent's attack to prevent the ball from touching the court and maintain the continuity of play [11,12]. A successful dig provides the team with an opportunity to organize an effective counterattack. According to Dieter (2007), the dig involves receiving the ball through an upward scooping movement and is particularly useful for handling difficult serves while allowing the player to direct the ball [13]. This skill requires not only correct movement techniques but also reaction speed, coordination, the ability to anticipate the opponent's attack, and adequate physical fitness. In modern volleyball, defensive performance is strongly supported by effective digging, which enables teams to transition from defense to attack [14]. Consequently, dig performance is an important indicator for evaluating individual athletes and overall team effectiveness.

To objectively evaluate training quality, the Index Overall Demand (IOD) can be used to assess the training demands experienced by individual athletes. According to Setiawan [15], IOD is a method for evaluating training quality or dosage to minimize the risk of overtraining and performance stagnation that may hinder athletic achievement. This method assesses physiological responses to training through heart rate and incorporates several variables, including volume, intensity, density, and complexity. In a study conducted by Setiawan [15] at the Bina Bolavoli Krian Club, the average IOD score over three training days was -64.42, which was classified as very poor. This finding indicated that the training provided was not adequately aligned with the athletes' needs, particularly because rest periods substantially exceeded active training time. These results provide an important baseline for understanding the potential of IOD as an evaluation tool for assessing training quality and examining its relationship with athletic performance. Furthermore, Altundag et al. [16] identified moderate-to-strong relationships between training loads, including jumping, acceleration, and deceleration, and match demands among elite female volleyball players, highlighting the importance of load monitoring for performance optimization.

Despite these findings, the relationship between training demands and specific technical performance remains insufficiently explored. Altundag et al. [16] emphasized the importance of monitoring training loads, but the relationship between these loads and specific defensive skills, particularly the dig, remains underexplored. Similarly, the systematic review by Rebelo et al. [17] on volleyball match demands highlighted variations in internal and external workloads according to playing position, including the predominantly defensive role of the libero, as well as differences between genders. However, the review also identified the need for further research linking training demands to specific technical indicators and match outcomes. Existing studies have largely focused on describing training loads or match demands rather than examining their relationships with measurable technical performance. In particular, research investigating the relationship between IOD and defensive dig performance among female volleyball players remains limited. This gap is important because understanding the association between training quality and defensive performance may help coaches develop training programs that are more measurable, efficient, and tailored to athletes' needs.

Therefore, this study aims to examine the relationship between the Index Overall Demand (IOD) and defensive dig performance among the women's volleyball team of PBV Hans Surabaya. By investigating this relationship, the study seeks to provide empirical evidence regarding whether training demands, as measured by IOD, are associated with athletes' defensive performance. The findings are expected to contribute to the evaluation of training programs and provide practical information for coaches when designing more targeted, measurable, and efficient training strategies to improve defensive skills. Furthermore, this study is expected to address the existing research gap by examining the relationship between a quantitative indicator of training demands and a specific technical performance outcome in women's volleyball.

2. MATERIAL AND METHODS

This quantitative study uses a correlational approach with an ex post facto design to examine the relationships between Index Overall Demand (IOD), physical performance, and defensive dig skills among 30 female volleyball players aged 12–18 years at PBV Hans Surabaya, selected through purposive sampling. The study will be conducted at GOR Fasha, Surabaya, from August to December 2026.

Data will be collected through observation, documentation, and physical and technical tests. IOD will be calculated from training volume, intensity, and density using the formula $IOD = Volume \times Intensity \times Density$. Physical performance will be assessed using the vertical jump, hand grip dynamometer, beep test (VO_2max), and defensive reaction-speed test.

Dig skills will be evaluated during three matches based on successful digs, success rate, ball direction, control, and rally continuity.

Data will be analyzed using the Shapiro–Wilk test, followed by Pearson or Spearman correlation as appropriate, with a significance level of $\alpha = 0.05$. Multiple linear regression and the coefficient of determination (R^2) will assess the combined relationships of IOD and physical performance with defensive dig skills.

3. RESULTS AND DISCUSSION

The respondents were aged 11–16 years, with the largest proportion aged 13 years (30.3%). Most athletes had a height of 158–163 cm (33.33%), while the most common score range was 49–58 (36.36%). Regarding body mass index (BMI), the majority of respondents had a normal BMI (81.8%), followed by overweight (9.1%), underweight (6.1%), and obesity (3.0%) (Table 1).

Tabel 1: Respondent Characteristics

Characteristics	Criteria	Frequency	Precentage
Age	11	3	9.10
	12	4	12.10
	13	10	30.30
	14	7	21.20
	15	8	24.20
	16	1	3.00
Height	134-139	1	3.03
	140-145	0	0.00
	146-151	4	12.12
	152-157	9	27.27
	158-163	11	33.33
	164-169	7	21.21
	170-175	1	3.03
Body Weight	29-38	1	3.03
	39-48	10	30.30
	49-58	12	36.36
	59-68	9	27.27
	69-78	1	3.03
Body Mass Index	Underweight	2	6.10
	Normal	29	87.90
	Overweight	2	6.10
	Obesity	0	0.00

Tabel 2: Descriptive Statistical Results

Variabel	Minimum	Maksimum	Mean	Standar Deviasi
Index Overall Demand	10.62	37.20	22.64	8.10
Beep Test Vo2max	28.80	39.50	33.59	2.70
Vertical Jump	231.00	260.00	244.42	5.30
Hand Grip	17.90	33.10	25.74	4.70
Defensive Skills (Dig)	55.00	85.00	65.90	6.50

Based on Table 2, descriptive statistics showed that the Index Overall Demand (IOD) had a mean of 22.6494 (SD = 8.145), ranging from 10.62 to 37.20. The mean VO₂max was 33.590 (SD = 2.744), while the vertical jump and hand grip had mean values of 244.424 (SD = 5.350) and 25.7424 (SD = 4.727), respectively. Defensive dig skills had a mean score of 65.9091 (SD = 6.568), with values ranging from 55 to 85. These findings summarize the central tendency and variability of the study variables.

Tabel 3: Correlation Between Index Overall Demand, Physical Performance, and Defensive Skills (Dig)

Variable Relationship	Correlation Coefficient	P-value	Interpretation
Index Overall Demand and Defensive Skills (Dig)	0.197	0.271	Not significant
Beep Test and Defensive Skills (Dig)	0.133	0.460	Not significant
Vertical Jump and Defensive Skills (Dig)	0.267	0.133	Not significant
Hand Grip and Defensive Skills (Dig)	0.511	0.002	Significant

Based on Table 3, IOD ($r = 0.197$; $p = 0.271$), VO₂max ($r = 0.133$; $p = 0.460$), and vertical jump ($r = 0.267$; $p = 0.133$) showed positive but statistically insignificant relationships with defensive dig skills. In contrast, hand grip strength showed a moderate, significant positive relationship ($r = 0.511$; $p = 0.002$).

Tabel 4: Multiple Linear Regression Analysis of Factors Associated with Defensive Dig Skills

Variable	Regression Coefficient (B)	t-value	P-value	Interpretation
Constant	-21.431	-0.436	0.666	Not significant
Index Overall Demand (IOD)	0.102	0.746	0.462	Not significant
Beep Test (VO ₂ max)	-0.386	-0.902	0.375	Not significant
Vertical Jump	0.325	1.613	0.118	Not significant
Hand Grip	0.721	2.808	0.009	Significant

Based on Table 4, the regression equation was $Y = -21.431 + 0.102X_1 - 0.386X_2 + 0.325X_3 + 0.721X_4$. Only hand grip strength significantly predicted defensive dig skills ($\beta = 0.721$; $p = 0.009$), while IOD ($p = 0.462$), VO₂max ($p = 0.375$), and vertical jump ($p = 0.118$) were not significant.

Tabel 5: Results of Simultaneous Linear Regression Analysis

Model	F-value	P-value	Interpretation
IOD and Physical Performance in Relation to Defensive Dig Skills	3.591	0.017	Significant

The simultaneous regression analysis in Table 5 showed a significant association between IOD and physical performance collectively and defensive dig skills ($F = 3.591$; $p = 0.017$). This indicates that the variables jointly contributed to explaining variations in defensive dig skills.

Tabel 6. Results of the Coefficient of Determination

Model	R	R Square (R ²)	Adjusted R Square
IOD and Physical Performance in Relation to Defensive Dig Skills	0.582	0.339	0.245

Based on Table 6, the R Square (R²) value was 0.339, indicating that Index Overall Demand (IOD) and physical performance jointly explained 33.9% of the variation in defensive dig skills, while the remaining 66.1% was explained by other factors not included in the research model.

The relationship between training demands and defensive dig skills may depend on the alignment between training activities and game requirements. IOD measures training volume, intensity, and density, whereas defensive performance relies on anticipation and reaction to opponents' attacks [11,18]. Thus, training demands may influence defensive skills indirectly through physical adaptation and technical practice. Setiawan [15] reported very low IOD among adolescent male volleyball players due to low training density and excessive rest periods. Similar patterns could limit differences in IOD among PBV Hans Surabaya athletes. However, Setiawan's IOD value (−64.42) cannot be directly compared with the present study's mean (22.65) because of differences in participants and calculation methods. IOD measurements may also reflect only a specific training period, whereas technical skills develop through long-term practice. Hanafi and Subagio [19] found moderate-to-high training demands that varied across sessions among East Java pencak silat athletes, emphasizing appropriate intensity and rest management. Although their study involved a different sport, it supports using IOD to evaluate training loads rather than as a direct indicator of defensive performance.

Physical fitness supports movement and responses during volleyball rallies, but its contribution to defensive skills depends on the specific demands of each action. General fitness tests may not fully represent an athlete's ability to receive and control an opponent's attack. Defensive digging requires anticipation, appropriate positioning, coordination, and precise timing in addition to physical capacity. These technical and perceptual abilities may not be captured by isolated physical performance tests. Therefore, physical conditioning should be integrated with defensive drills that simulate different attack directions and match situations. This approach may help athletes combine physical readiness with the technical coordination required for effective defense, although further intervention studies are needed to evaluate its effectiveness.

Hand grip strength may support ball reception by contributing to upper-limb control and forearm stability. Pawlik et al. [20] reported a significant positive relationship between left-hand grip strength and serve-reception efficiency among female volleyball players. Similarly, Lee et al. [21] found a significant positive relationship between grip strength and defensive and reception abilities in sitting volleyball athletes. Although these studies did not directly assess conventional volleyball digging, they provide supporting evidence for the potential relevance of grip strength. Effective digging requires a stable forearm platform and appropriate arm positioning to control the ball. However, grip strength alone does not measure defensive technique, which also depends on body positioning, arm angle, coordination, anticipation, and timing. Accordingly, grip-strength training may complement technical defensive exercises. Nevertheless, the observed relationship does not establish that increasing grip strength directly improves digging performance. Further intervention studies are required to examine this possibility.

The relevance of vertical jump ability may vary according to players' positions and tactical responsibilities. Bunn et al. [22] found that relationships between physical fitness and volleyball performance differed by playing position and performance indicators, including a specific relationship between vertical jump ability and defensive digs among outside hitters. These findings suggest that jumping ability may be relevant in particular playing roles. Defensive digging often requires lateral movement, low body positioning, and precise ball control rather than vertical displacement. Therefore, general jumping tests may not adequately represent the movements required for successful digging. The relevance of vertical jump ability should be interpreted according to playing position and defensive demands [22]. Ho et al. [23] developed a system to evaluate digging agility and examined plyometric training among 24 male collegiate volleyball players. Their study distinguished sport-specific defensive agility from general fitness components, including explosive power, sprinting, and agility. Although this does not exclude a relationship between vertical jump and digging, it highlights the importance of assessing defensive skills specifically [23].

Aerobic capacity supports sustained activity and recovery during repeated exercise. However, defensive digging also requires anticipation, reaction speed, agility, and technical accuracy, which cannot be fully represented by VO₂max alone. Brumitt et al. [24] found that certain physical fitness components, particularly agility and dynamic balance, were associated with match-performance indicators, including defensive digs, among female volleyball athletes. Although their study did not directly examine VO₂max, the findings highlight the potential importance of physical attributes that support rapid movement and body control. Therefore, aerobic conditioning should be combined with technical drills

that develop anticipation, reaction speed, positioning, and ball control. Further research is needed to determine whether aerobic capacity contributes to defensive performance under different match conditions.

Volleyball performance involves physical abilities, technical execution, and decision-making. Salles et al. [25] analyzed 44,025 technical-tactical actions in U-15, U-16, and U-17 volleyball matches and found that performance was associated with decision-making, adaptation, technical efficiency, and competition level. Their model explained 51.40% of the variation in technical-tactical effectiveness, highlighting the importance of factors beyond physical fitness and training demands. Psychological readiness may also influence performance. Shieh et al. [26], studying 81 male collegiate volleyball players, found that mental energy was associated with several match-performance indicators. Their regression analysis showed that mental energy predicted reception performance, with an R^2 of 0.23. Although defensive digging was not specifically examined, concentration, confidence, and decision-making may be relevant to defensive performance [26]. The unexplained variation in the present model should not be attributed to any specific factor without further evidence. Instead, it indicates that IOD and the included physical variables do not fully explain differences in defensive digging. Future studies should consider technical, tactical, perceptual, and psychological variables.

The findings support an integrated approach to defensive skill development that combines training-load management, physical conditioning, and technical practice. Increasing training volume or intensity alone may not improve defensive performance because successful digging also requires anticipation, positioning, and ball control. These recommendations should be evaluated through further research. Cossich et al. [27] discussed the use of technology, data analysis, and visualization to evaluate sports performance systematically. In volleyball, match-video analysis could assess digging attempts, success rates, ball-control quality, positioning, and responses to different attacks, complementing standardized skill tests [27].

Several limitations should be acknowledged. First, the correlational design cannot establish causality. Second, the single-club sample limits generalizability to other female volleyball athletes. Third, measurements from a specific training period may not represent training demands over an entire program. Fourth, standardized tests may not capture match complexity, decision-making, and team coordination. Future research should involve multiple clubs, monitor IOD longitudinally, combine defensive tests with match-video analysis, and examine additional technical, tactical, and psychological variables.

4. CONCLUSION

Based on the research findings, it can be concluded that there was no significant relationship between the Index Overall Demand (IOD) and defensive dig skills among the female volleyball team of PBV Hans Surabaya. In contrast, physical performance was significantly associated with defensive dig skills, indicating that physical performance plays a role in athletes' defensive abilities. Furthermore, the Index Overall Demand (IOD) and physical performance were jointly and significantly associated with defensive dig skills, although their contribution was also influenced by other factors not included in the research model. Therefore, the findings do not support the hypothesis of a significant partial relationship between IOD and defensive dig skills but support the hypotheses of a significant relationship between physical performance and defensive dig skills, as well as a significant simultaneous relationship of IOD and physical performance with defensive dig skills.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of informed consent

Participation in this study was voluntary, and informed consent was obtained from the participants and their parents or guardians, as applicable.

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