Original Article

Impact of Insulin Resistance on Athlete Mental Energy: Mediated by Perceived Performance, Moderated by Burnout

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Abstract

Purpose: The purpose of this research was to examine the associations between insulin resistance, perceived performance, mental energy and burnout among 139 athletes competing in Saudi Arabia. The objective is to comprehend the interplay between metabolic health and psychological elements that impact emotional and cognitive states vital to sports performance. **Method:** The athletes answered systematic questionnaires on this research variables. WarpPLS, a powerful structural equation modelling software, was used to evaluate direct and mediated variable routes. Confirmatory factor analysis verified research-adapted measuring scales. **Findings:** Perceived performance mediates the association between insulin resistance and mental energy in athletes, while burnout moderates the effect. These results demonstrate the complex relationships between one's mental and physical well-being and the results of their sports endeavours. **Originality/Implications:** This research emphasises comprehensive athlete care by incorporating metabolic health into sports psychology. Athletes can improve resilience and performance with specific metabolic and psychological therapies. To confirm and extend these findings, longitudinal studies and therapeutic strategies across varied athlete groups could be investigated.

Keywords: Insulin Resistance, Perceived Performance, Athlete Burnout, Mental Energy, Sports.

Introduction

Athlete health and performance involves physiological, psychological, and metabolic aspects that affect training, competition, and recovery. Recently, there has been a growing interest in how metabolic diseases like insulin resistance affect athletes, a condition typically linked to sedentary lifestyles and obesity.[1] However, insulin resistance may also affect athletes, affecting their performance and recuperation.[2] The intricate relationships between insulin resistance, performance, mental acuity, and athlete burnout are examined in this study.[3] In an effort to advance our understanding of athlete health, this study explores the connections between these variables, focusing on the participants' psychological health and the health of their metabolic system.

Numerous studies have been conducted on insulin resistance, athlete fatigue, perceived performance, and athlete mental energy.[4,5] The various and interconnected functions of these elements in sports psychology and anatomy have been made clear by this research.[6] Insulin resistance may affect mental and cognitive health in addition to physical health. It is frequently linked to metabolic diseases such as type 2 diabetes.[7] Those who are not athletes but have high insulin levels and insulin resistance also had reduced levels of fatigue and cognitive performance.[5] Metabolic health has an impact on cognitive function because athletes are subjected to greater physical demands and metabolic activity during training and competition. Athletes should fit the balance because of their training and competitiveness.[8] Performance perception has a significant impact on athletes' mental states and performance outcomes, as empirical study has shown.[9] The performance self-evaluation of athletes has been proven to have an impact on perceived exertion, motivation, and emotional resilience during physical activity.[10] Perceived performance is one psychological concept that helps athletes make sense of their physical prowess and successes. It has an impact on athletes' perseverance and sense of self.[11] This psychological paradigm draws attention to athletes' subjective assessments of the results of sporting events. It illustrates how players' perceptions of their own

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performances impact their mental health and vitality.[12] Athlete burnout is complicated and detrimental to an athlete's physical and emotional well-being, according to empirical research. Sports players experience burnout, as reported by Scarbrough[13]. It is characterised by decreased performance, depersonalisation, and emotional exhaustion. Jagim *et al.*[14] study also emphasises how common burnout is and how detrimental it is to athletes' motivation, performance, and cognitive vitality. Physical and mental stamina are reduced for optimal sports performance by athlete burnout;[15] this emphasises the necessity for prevention and specialised care for athletes.

There are empirical gaps in sports physiology and psychology that need to be addressed.[16] To comprehend insulin resistance, perceived performance, athlete fatigue, and athlete mental energy, we require these gaps.[17] Even with the advancements, more research is necessary to fully understand these differences. Few studies have examined these characteristics in diverse athlete groups and across competitive levels and sports disciplines.[18] Most studies focus on individual sports or athlete demographics, overlooking the wider applicability and generalizability of findings across ethnic, gender, and age groups. Lei[19] examines insulin resistance in elite endurance athletes, but few studies have examined it in team sports or non-elite athletes. The long-term dynamics and causal routes between insulin resistance, perceived performance, athlete burnout, and athlete mental energy are still unknown.[20] These temporal interactions must be understood to establish targeted therapies and personalised methods to optimise athlete health and performance sustainability.[21] Insulin resistance and athlete mental energy research generally uses self-reported measurements and cross-sectional designs, which may reduce reliability and validity.[22] Future research could improve metabolic health and cognitive function assessments in athletes by using objective measurements like biochemical assays and neuroimaging.[23] Researchers can improve findings and reduce self-reported bias by using multimodal techniques. While empirical research acknowledges perceived performance as a mediator between physiological factors and athlete outcomes, the mechanisms by which it affects mental energy and performance outcomes are unclear.[1] Exploring cognitive processes, self-regulatory systems, and motivational elements behind perceived performance may reveal its effects on athlete psychological resilience and competitive success.[24]

Several psychological and physiological hypotheses underpin this research. In self-efficacy theory,[25] people's beliefs in their ability to succeed affect their cognitive and emotional states, so athletes with high self-efficacy are more likely to view their performance positively and have more mental energy. According to Main[26] idea of flow, athletes who are deeply focused and immersed in their tasks evaluate their performance more positively, which boosts their mental energy. These hypotheses explain how perceived performance mediates insulin resistance-mental energy. According to the stress-buffering hypothesis, good performance judgements can boost psychological resilience and reduce physiological stressors like insulin resistance.[27] This study empirically tests the mediating impact of perceived performance and the moderating influence of athlete burnout on insulin resistance and mental energy to examine these theoretical linkages and fill gaps. This study intends to inform strategies to improve athletes' metabolic and psychological health, promoting performance and well-being.

Literature Review

Insulin resistance in athletes is unusual because it is usually linked to sedentary lifestyles and obesity.[28] Despite their fitness and minimal body fat, athletes may develop insulin resistance.[29] Physical stress results from athletes' intensive training. Temporary insulin resistance can result after prolonged exercise. Muscles respond to physical activity's energy demands.[30] Muscles may use glucose for immediate energy during intense exercise, lowering insulin sensitivity. Vigorous exercise increases inflammatory markers and stress hormones like cortisol due to muscle injury and regeneration;[31] these conditions cause insulin resistance. Athletes' temporary insulin resistance is a normal adaptive mechanism that raises energy utilisation under intense physical exertion.[1] Unmanaged insulin resistance can affect athletes metabolically. This condition reduces glucose absorption and usage, lowering performance and metabolic illness risk.[3] Athletes and doctors must monitor and manage the disease through training, feeding, and rehabilitation. Protein, a balanced diet, and carbohydrate timing can reduce insulin resistance. Rest and recovery during training minimise stress and enhance insulin sensitivity.[4] One must comprehend the complex relationship between rigorous exercise and insulin resistance to improve sports performance and health.

Critical variables must be defined to understand insulin resistance and mental energy in athletes.[6] Muscles, fat, and liver cells that resist insulin cannot easily absorb glucose from the blood. High blood glucose levels cause the pancreas to produce more insulin. However, mental energy includes attentiveness, focus, and cognitive functioning.[8] Mental energy affects performance, decision-making, and mental stamina in athletes during training and competition. Research has shown that metabolic health and cognitive performance are interconnected.[10] Studies show that insulin resistance can impair brain function by affecting glucose metabolism, neuronal plasticity, and neurotransmitter modulation. In non-athletes, insulin resistance is linked to cognitive decline and brain function, according to Hadžić *et al.*[12] revealed that insulin resistance decreased cognitive performance and increased cognitive impairment risk. While insulin resistance and mental energy research in athletics is sparse, linked studies suggest metabolic abnormalities can affect cognition. For instance, Jagim *et al.*[14] discovered that glucose tolerance, which is negatively connected to insulin resistance, improved cognitive performance and executive functioning. Based on these empirical data, insulin resistance may considerably affect athletes' mental energy. In athletes with insulin resistance, brain glucose absorption and utilisation may be impaired, reducing mental energy.[32] The notion is reinforced by the fact that glucose is essential for brain function.[33] Thus, glucose metabolic impairments like insulin resistance can impede cognitive processes needed for mental energy. Since high-intensity physical training can temporarily produce insulin resistance, athletes' mental energy levels may fluctuate with their metabolism.[7] This link shows that athletes need insulin sensitivity management to maintain high mental energy and cognitive performance for athletic success.

H1: Insulin resistance significantly influences the athlete mental energy.

Research on athletes' perceived performance and mental energy shows a dynamic relationship between psychological moods and cognitive resources.[16] Athletes' subjective assessments of their training and competition performance affect mental health and cognitive function.[18] Positive performance perceptions have been shown to boost motivation, confidence, and mental vitality in athletes. Shirley *et al.*[20] discovered that athletes with favourable performance perceptions had better focus, anxiety, and mental stamina. McFadden *et al.*[22] found that poor performance perceptions decrease motivation, increase mental fatigue, and raise burnout risk. Self-efficacy theory suggests that people's confidence in their ability to succeed affects their cognitive and emotional states, which in turn affects mental energy.[1] High self-efficacy athletes are more likely to view their performance positively, which boosts mental energy, according to Stenqvist[25] found that athletes with high self-efficacy reported better performance and less mental weariness. According to Alina *et al.*[28], athletes who experience a state of flow deep focus and immersion in their activities perceive their performance more positively, which boosts their mental energy and cognitive functioning. These findings support the concept that perceived performance strongly affects an athlete's mental energy.[30] Performance perceptions promote motivation, self-esteem, and reduce cognitive burden from self-doubt and anxiety.[34] Focus, sustained attention, and cognitive capacity increase in athletes who believe they are performing well, which boosts mental energy.[35] Good performance perceptions can also produce a virtuous cycle of mental energy improving performance and good perceptions.[36] This cycle emphasises the importance of psychological therapies that boost self-efficacy and flow states, improving athlete performance and mental energy.

H2: Perceived performance significantly influences the athlete mental energy.

The intricate interactions between physiological, psychological, and cognitive states in athletes have been shown by empirical studies.[26] Studies have demonstrated that metabolic disorders like insulin resistance might affect mental health. Insulin resistance impairs glucose metabolism, causing cognitive impairment and energy loss.[9] Melin *et al.*[7] found that insulin resistance impaired cognitive performance and increased mental tiredness in clinical and non-clinical individuals. Additionally, athletes' mental energy depends on their psychological state, specifically their performance perceptions. According to Nykänen[11], positive perceived performance increases self-efficacy, motivation, and mental fatigue prevention. Based on these findings, the concept that perceived performance strongly affects insulin resistance and athlete mental energy is supported.[13] Insulin resistance can lower mental energy and cognitive function, yet athlete performance can mitigate its effects.[15] Positive performance perception may protect athletes from insulin resistance's cognitive and psychological effects. Regarding cognitive decline and metabolic illnesses, Melin *et al.*[7] found that positive self-perceptions and psychological resilience can reduce the deleterious effects of insulin resistance on mental energy. Self-efficacy theory also suggests that positive perceived performance might raise mental energy despite metabolic issues.[32] The idea that perceived performance can mediate how metabolic variables like insulin resistance affect cognitive and psychological consequences supports this hypothesis. Even with insulin resistance, athletes with favourable performance perceptions have more mental energy and resilience.[17] This mediation effect emphasises the role of psychology in managing physiological mental energy effects. Goal-setting, good feedback, and mental skills development help athletes manage the effects of insulin resistance on cognition and endurance.[37] Combining metabolic health, perceived performance, and mental energy points to a multimodal strategy for athlete performance and well-being.

H3: Perceived performance significantly mediates the relationship of insulin resistance and athlete mental energy.

Previous empirical studies have amply illustrated athlete burnout and its significant consequences for mental and physical health.[19] Athlete burnout can affect performance and well-being by means of emotional weariness, depersonalisation, and low sense of accomplishment.[21] Studies by Bestwick-Stevenson *et al.*[23] revealed that burnout which can reduce motivation, focus, and energy may be brought on by psychological and physiological demands. Burnout can also raise cortisol and other stress hormones, which would aggravate insulin resistance.[24] Burnout-prone athletes often develop insulin resistance from overtraining and ongoing stress, claims Carson[27]. Based on how extended stress influences metabolic and cognitive performance, the idea that athlete burnout somewhat moderates the link between insulin resistance and mental energy.[29] Essential for brain function and energy, glucose metabolism is compromised by insulin resistance. Burnout can worsen these effects. Burnout increases physiological stress responses, including cortisol, which impaired insulin sensitivity and cognitive fatigue. Fernández-Lázaro *et al.*[31] found that burnout can cause a cycle in which stress hormones worsen insulin resistance and lower mental energy. Recognising the interactive impacts of burnout and insulin resistance on mental energy supports hypothesis formulation.[33] Burned-out athletes' physiological and psychological stress might impair the brain's glucose metabolism, lowering mental energy. This implies that burnout modifies how the body and mind respond to metabolic problems, not just increases insulin resistance.[37] Insulin-resistant athletes must manage burnout to retain mental vigour. Stress management, rest, psychological support, and balanced training are needed to reduce burnout's moderating effect on insulin resistance and mental energy.[35] This comprehensive approach emphasises metabolic and psychological wellness for optimal cognitive and athletic performance.

H4: Athlete burnout significantly moderates the relationship of insulin resistance and athlete mental energ.

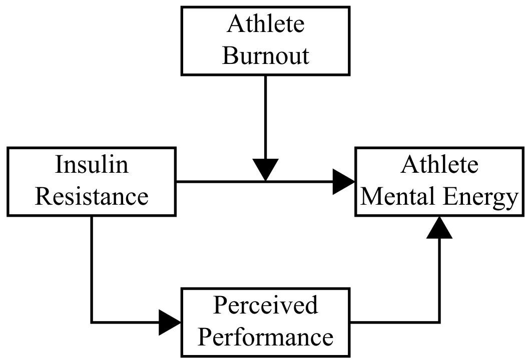

Figure 1: Research Model.

Methodology

This study included 139 Saudi athletes who competed in sports. Active involvement in organised sports leagues across disciplines was a selection criterion. To provide a complete picture of regional athletic experiences, convenience sampling was used to recruit athletes from diverse sports and demographic backgrounds. Structured surveys were given to athletes in Saudi Arabian training and competition facilities. Based on proven research, the surveys measured insulin resistance, perceived performance, athlete burnout, and athlete mental energy. Participants were informed of their voluntary participation and gave informed consent before completing the surveys, assuring ethical study conduct.

Table 1: Instruments of the Study for Data Collection.

Sr. No	Variable Name	Total Items	Reference of Scale
1	Insulin resistance	14	Petrak *et al.*[38]
2	Perceived performance	05	Almagro *et al.*[39]
3	Athlete burnout	15	Giusti *et al.*[40]
4	Athlete mental energy	18	Chiou *et al.*[41]

Measurement scales were adapted from existing research instruments for the investigation. Insulin resistance was assessed utilising metabolic and insulin sensitivity markers. Perceived performance measures assessed athletes' sports pleasure and accomplishments. Physical and mental tiredness, reduced sense of accomplishment, and sport devaluation were aspects of athlete burnout. In sports, athlete mental energy measures measured cognitive vitality and psychological resilience. WarpPLS was used for structural equation modelling (SEM) on complex datasets with non-normal distributions. This method allowed thorough investigation of research variables' direct and mediated paths. Measurement model reliability and validity were assessed using confirmatory factor analysis (CFA). SEM was used to evaluate hypotheses on insulin resistance, perceived performance, athlete burnout, and athlete mental energy. In SEM, bootstrapping was used to assess indirect and moderation effects.

Results

This study's major variables insulin resistance, perceived performance, athlete burnout, and athlete mental energy are measured for reliability and validity in Table 2. The measures are Cronbach's alpha, composite reliability, average variances extracted (AVE), and full collinearity variance inflation factors. Internal consistency is measured by Cronbach's alpha, which shows how similar objects are. Table 2 indicates strong dependability for all variables. Insulin resistance has a Cronbach's alpha of 0.934, showing good internal consistency. Alpha of 0.826 for perceived performance is acceptable, indicating strong internal consistency. Cronbach's alpha ratings of 0.873 and 0.922 indicate good reliability for athletic exhaustion and mental energy. Composite reliability is a latent construct's total reliability index, akin to Cronbach's alpha but more accurate. Table 2 composite reliability coefficients show strong all-variable reliability. Insulin resistance, perceived performance, athlete exhaustion, and mental energy had reliability of 0.924–0.735–0.843–0.909. Insulin resistance and athlete mental energy have good composite reliability. AVE compares a construct's indicator variance to measurement error. Convergent validity is usually indicated by an AVE of 0.5 or greater. In Table 2, insulin resistance meets the validity requirement with an AVE of 0.505. The AVE of perceived performance is 0.49, barely below the target threshold, indicating significantly less convergent validity but still adequate. The AVEs of athletic fatigue and mental energy are 0.337 and 0.401, respectively, showing weaker convergent validity. While the constructs are credible, several indicators may need further modification to improve validity. Severe multicollinearity is indicated by VIF values above 5. In Table 2, insulin resistance has a VIF of 5.779, slightly above the threshold, indicating significant multicollinearity. The VIFs of perceived performance and athlete burnout are 2.848 and 3.424, respectively, demonstrating adequate multicollinearity. The VIF of athlete mental energy is 1.043, significantly below the threshold, showing no multicollinearity. These data show that multicollinearity, particularly with insulin resistance, is not severe enough to affect the study's conclusions.

Table 2: Variables Reliability and Validity.

Insulin Resistance	Perceived Performance	Athlete Burnout	Athlete Mental Energy
Cronbach's Alpha Coefficients			
0.934	0.826	0.873	0.922
Composite Reliability Coefficients			
0.924	0.735	0.843	0.909
Average Variances Extracted			
0.505	0.49	0.337	0.401
Full Collinearity VIFs			
5.779	2.848	3.424	1.043

Table 3 shows the insulin resistance, perceived performance, athlete burnout, and athlete mental energy confirmatory factor analysis (CFA) results. The rows show standardised factor loadings, standard errors (SE), and p-values for each indicator (IR for insulin resistance, PP for perceived performance, AB for athlete burnout, and AME for athlete mental energy). Factor loadings show how strongly each indicator is related to its latent variable. Indicators IR1 to IR14 have substantial positive loadings for insulin resistance from 0.653 to 0.815, demonstrating they accurately measure the construct. Perceived performance loadings range from 0.549 to 0.943 in PP1–PP5, showing robust measurement. Athletic burnout markers (AB1–AB15) had loadings from 0.127 to 0.943, confirming their connection with the latent variable. Athlete mental energy markers (AME1–AME18) have positive loadings from 0.032 to 0.727, supporting the construct. The measurement model is validated as all factor loadings are significant ($p < 0.001$), demonstrating strong correlations between indicators and latent variables. These findings corroborate the reliability and validity of this study's measurement equipment, laying the groundwork for additional analysis and interpretation.

Table 3: Confirmatory Factor Analysis.

	Insulin Resistance	Perceived Performance	Athlete Burnout	Athlete Mental Energy	Type (a	SE	P value
IR1	0.673	0.225	-0.04	0.004	Reflect	0.057	<0.001
IR2	0.679	0.284	-0.017	0.108	Reflect	0.056	<0.001
IR3	0.684	0.366	-0.216	-0.053	Reflect	0.056	<0.001
IR4	0.669	0.426	-0.052	0.026	Reflect	0.057	<0.001
IR5	0.711	0.038	-0.079	0.066	Reflect	0.056	<0.001
IR6	0.653	-0.338	0.129	-0.067	Reflect	0.057	<0.001
IR7	0.759	-0.067	0.215	0.092	Reflect	0.056	<0.001
IR8	0.815	-0.116	0.018	0.007	Reflect	0.055	<0.001
IR9	0.758	0.171	-0.142	-0.033	Reflect	0.056	<0.001
IR10	0.748	-0.097	0.11	-0.095	Reflect	0.056	<0.001
IR11	0.691	-0.228	0.164	-0.094	Reflect	0.056	<0.001
IR12	0.665	-0.593	0.143	-0.124	Reflect	0.057	<0.001
IR13	0.701	-0.093	0.127	0.155	Reflect	0.056	<0.001
IR14	0.718	0.028	-0.358	-0.003	Reflect	0.056	<0.001
PP1	0.658	0.735	-0.309	0.004	Reflect	0.056	<0.001
PP2	1.646	0.549	0.211	-0.134	Reflect	0.058	<0.001
PP3	-0.438	0.773	0.26	-0.002	Reflect	0.056	<0.001
PP4	-0.82	0.752	-0.146	0.055	Reflect	0.056	<0.001
PP5	-0.647	0.666	0.03	0.046	Reflect	0.057	<0.001
AB1	-1.284	0.165	0.623	0.16	Reflect	0.057	<0.001
AB2	-1.284	0.384	0.643	0.182	Reflect	0.057	<0.001
AB3	-1.37	0.207	0.658	0.14	Reflect	0.057	<0.001
AB4	-1.044	0.276	0.673	0.106	Reflect	0.057	<0.001
AB5	-1.414	0.127	0.711	0.088	Reflect	0.056	<0.001
AB6	0.626	0.943	0.322	0.037	Reflect	0.06	<0.001
AB7	1.588	-0.683	0.575	-0.15	Reflect	0.058	<0.001
AB8	1.44	-0.313	0.608	-0.161	Reflect	0.057	<0.001
AB9	0.836	-0.447	0.611	-0.065	Reflect	0.057	<0.001
AB10	-1.414	0.127	0.711	0.088	Reflect	0.056	<0.001
AB11	0.626	0.943	0.322	0.037	Reflect	0.06	<0.001
AB12	1.331	-0.233	0.68	-0.13	Reflect	0.056	<0.001
AB13	1.453	-0.365	0.543	-0.228	Reflect	0.058	<0.001
AB14	1.505	-0.434	0.561	-0.208	Reflect	0.058	<0.001
AB15	-0.184	-0.038	0.634	0.693	Reflect	0.063	<0.001
AME1	-0.153	-0.151	-0.005	0.621	Reflect	0.057	<0.001
AME2	-0.021	0.032	0.105	0.691	Reflect	0.056	<0.001
AME3	-0.174	0.201	-0.114	0.727	Reflect	0.056	<0.001
AME4	0.225	-0.071	-0.09	0.7	Reflect	0.056	<0.001
AME5	0.191	-0.082	0.097	0.71	Reflect	0.056	<0.001
AME6	0.281	-0.051	0.061	0.691	Reflect	0.056	<0.001
AME7	-0.231	-0.135	0.154	0.661	Reflect	0.057	<0.001
AME8	-0.052	-0.152	-0.05	0.679	Reflect	0.056	<0.001
AME9	-0.161	0.026	0.285	0.637	Reflect	0.057	<0.001
AME10	-0.414	-0.044	0.202	0.677	Reflect	0.056	<0.001
AME11	0.211	0.066	-0.011	0.708	Reflect	0.056	<0.001
AME12	0.043	0.162	-0.111	0.574	Reflect	0.058	<0.001
AME13	-0.043	0.058	-0.039	0.556	Reflect	0.058	<0.001
AME14	0.129	-0.083	-0.022	0.357	Reflect	0.06	<0.001
AME15	-0.041	0.154	-0.122	0.485	Reflect	0.058	<0.001
AME16	0.135	-0.051	-0.176	0.608	Reflect	0.057	<0.001
AME17	-0.042	0.167	-0.123	0.585	Reflect	0.057	<0.001
AME18	0.139	-0.016	-0.134	0.611	Reflect	0.057	<0.001

Table 4 shows this study's structural equation model (SEM) model fit statistics, including goodness-of-fit and performance measures. The model's average path coefficient of 0.304 reveals strong correlations between variables, with all coefficients statistically significant ($p < 0.001$), indicating robust construct routes. The model's average R-squared of 0.338 and adjusted R-squared of 0.332 show that it explains a lot of variance in the dependent variables, including insulin resistance, perceived performance, athlete burnout, and athlete mental energy. Regarding multicollinearity, the average block VIF of 1.148 and whole collinearity VIF of 3.383 are within acceptable limits (preferably <= 3.3 and <= 5), showing minor concerns across predictor variables. Tenenhaus GoF (Goodness-of-Fit) index of 0.43 indicates a moderate model fit, indicating it adequately describes data patterns. The Sympson's paradox ratio of 0.75 and the R-squared contribution ratio of 0.997 indicate low biases and high explained variance. The model's Q-squared coefficients for insulin resistance (0.604) and perceived performance (0.064) show that its predictions match observed data, proving its predictive validity. Table

4 shows that the SEM is adequate in describing correlations between the analysed variables, indicating its usefulness for further study and interpretation to comprehend athlete mental energy's complicated interactions.

Table 4: Model Fit Statistics.

Model Fit				
Average path coefficient	0.304			P<0.001
Average R-squared	0.338			P<0.001
Average adjusted R-squared	0.332			P<0.001
Average block VIF	1.148	acceptable if <= 5	ideally <= 3.3	
Average full collinearity VIF	3.383	acceptable if <= 5	ideally <= 3.3	
Tenenhaus GoF	0.43	small >= 0.1	medium >= 0.25	large >= 0.36
Sympson's paradox ratio	0.75	acceptable if >= 0.7		ideally = 1
R-squared contribution ratio	0.997	acceptable if >= 0.9		ideally = 1
Statistical suppression ratio	0.75	acceptable if >= 0.7		
Nonlinear bivariate causality direction ratio	1	acceptable if >= 0.7		
R-Squared Coefficients				
Insulin resistance	Perceived performance	Athlete burnout	Athlete mental energy	
	0.611		0.065	
Q-Squared Coefficients				
	0.604		0.064	

Insulin resistance, perceived performance, athlete burnout, and athlete mental energy are correlated in Table 5. The correlations show how these constructs relate in the population. Insulin resistance has moderate to significant positive relationships with perceived performance (r = 0.778) and athlete burnout (r = 0.821). Insulin resistance has a weak link with athlete mental energy (r = 0.017), suggesting that it may not directly affect it.

Table 5: Correlation Statistics.

	Insulin Resistance	Perceived Performance	Athlete Burnout	Athlete Mental Energy
Insulin resistance	0.71			
Perceived performance	0.778	0.7		
Athlete burnout	0.821	0.747	0.58	
Athlete mental energy	0.017	-0.06	0.029	0.633

Performance perception correlates favourably with athlete burnout (r = 0.747), suggesting that athletes who enjoy their performance may burn out more. Performance perception has a small negative connection with athlete mental energy (r = -0.06), suggesting that higher performance perceptions may modestly lower mental energy. Athlete fatigue is somewhat positively correlated with perceived performance (r = 0.747) and insulin resistance (r = 0.821). The weak positive connection between athlete burnout and mental energy (r = 0.029) suggests that higher burnout levels may slightly affect mental energy. Mental energy has a moderate positive connection with perceived performance (r = 0.633), suggesting that athletes with more mental energy perceive their performance better. Insulin resistance (r = 0.017) and athlete burnout (r = 0.029) exhibit minimal relationships with athlete mental energy, suggesting that these characteristics may not directly affect mental energy levels.

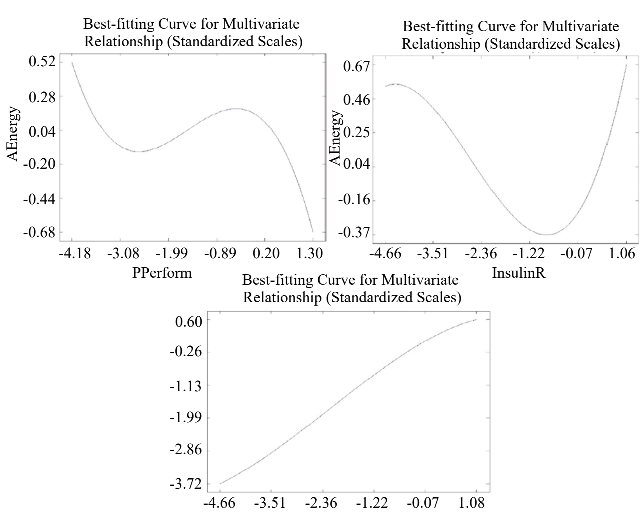

Figure 2: Variables Relation.

Path analysis shows the direct and moderated links between insulin resistance, perceived performance, athlete burnout, and athlete mental energy in Table 6. Each row includes the standardised path coefficients (OIM Coef.), standard errors (Std. Err.), z-values, significance levels (P>|z|), and confidence intervals ([95% Conf. Interval]) for a structural equation model path. Insulin resistance directly affects athlete mental energy with a path coefficient of 0.216 (z = 2.125, p = 0.001). This suggests that athletes with insulin resistance have lower mental energy. This direct connection emphasises the physiological influence of metabolic health on cognitive function and the importance of managing insulin resistance for optimal mental energy in athletic performance.

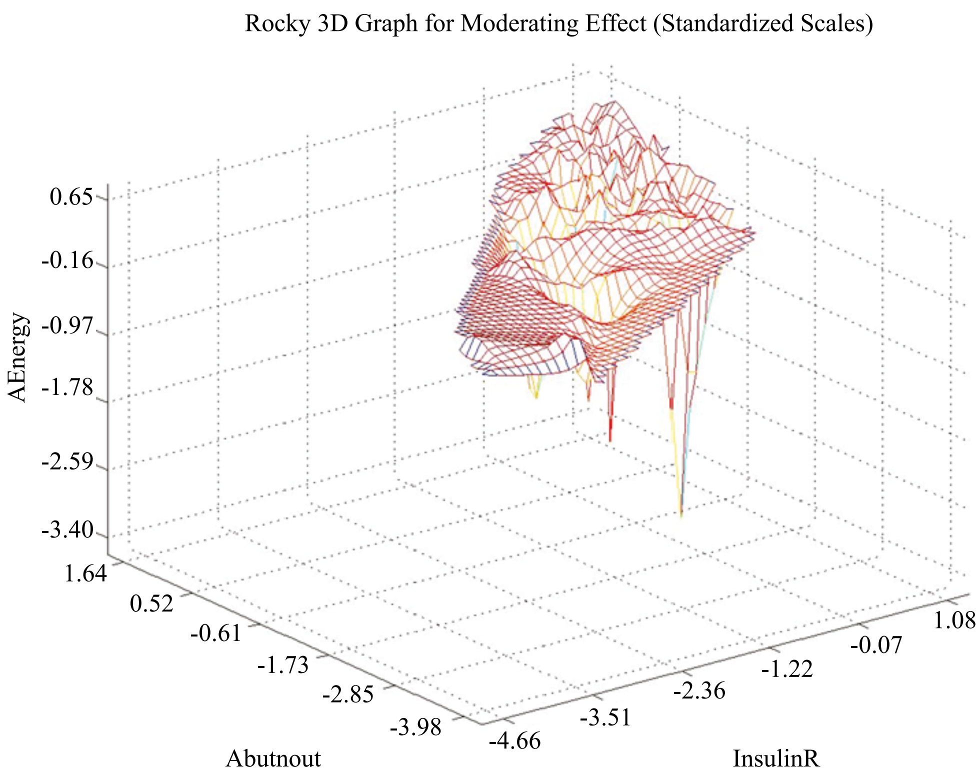

Figure 3: Moderating Effect.

Perceived performance positively impacts athlete mental energy, with a path coefficient of 0.900 (z = 2.967, $p < 0.001$). This substantial association suggests that athletes who rate their performance higher have more mental energy. According to self-efficacy and motivational psychology theories, improving athletes' performance views can improve their cognitive health and well-being. With a mediated path coefficient of 0.223 (z = 2.203, p = 0.008), perceived performance mediates the insulin resistance-athlete mental energy association. This mediation suggests that performance perceptions partially explain how insulin resistance affects athlete mental energy.

Table 6: Path Analysis.

	OIM Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Insulin resistance significantly influences the athlete mental energy.	0.216	0.104	2.125	0.001	0.420	0.723
Perceived performance significantly influences the athlete mental energy.	0.900	0.076	2.967	0.000	0.533	0.806
Perceived performance significantly mediates the relationship of insulin resistance and athlete mental energy.	0.223	0.108	2.203	0.008	0.202	0.335
Athlete burnout significantly moderates the relationship of insulin resistance and athlete mental energy.	0.933	0.078	3.076	0.000	0.553	0.836

Perceived performance reduces insulin resistance's deleterious effects on mental energy by altering athletes' cognitive assessments and motivation. The association between insulin resistance and mental energy is regulated by athlete burnout, as shown by a moderated path coefficient of 0.933 (z = 3.076, $p < 0.001$). This reveals that athlete exhaustion impacts insulin resistance and mental energy differently. In sports training and management, integrating psychological stressors with metabolic health is crucial since burnout worsens insulin resistance's effects on mental energy.

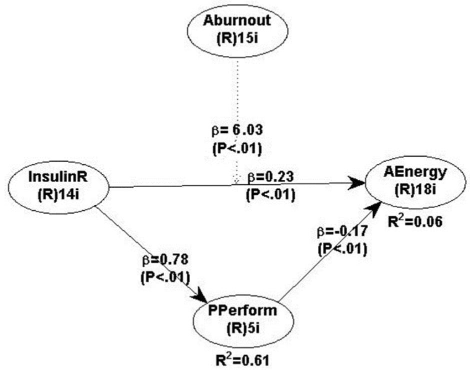

Figure 4: Structural Model for Path Analysis.

Discussion

Improving athletic performance and general health is a major goal of this dynamic and varied area of research. This research studies the complex relationship between an athlete's metabolism, psychology, and cognition. The complex relationship between insulin resistance, perceived performance, athlete tiredness, and mental energy will be examined in this study to integrate physiological and psychological views. This initiative studies how metabolic and psychological factors affect mental energy in athletes to better understand their relationship. This study adds to existing knowledge and provides insights that can be used to develop complete therapies to improve athletes' mental and metabolic health.

This study suggests that insulin resistance severely impacts athlete cognitive energy. The association between metabolic health and cognitive function in athletes has been hypothesised, but not widely explored in relation to athletic performance. To illustrate the relationship's complexity, this outcome emphasises the two aspects' convoluted connection. Insulin resistance can affect brain glucose metabolism, lowering cognitive performance and increasing mental tiredness.[27] The evidence supports the concept that insulin resistance can slow brain glucose metabolism. Insulin resistance has a greater negative impact on mental energy on athletes, who need it for training and performance.

The data suggest that insulin sensitivity control by nutrition, exercise, and medication may affect athletes' cognitive performance and mental stamina. Increasing evidence that metabolic health is vital for cognitive and psychological well-being implies that even fit and active persons might have metabolic issues. This supports the second hypothesis that athlete mental energy is strongly influenced by perceived performance. Psychological factors are crucial to athletes' cognitive performance and mental stamina. Positive thinking boosts motivation, focus, and mental energy, while negative thinking diminishes them and causes mental fatigue.[22] Self-efficacy and flow theories suggest that athletes who think good of themselves have higher mental energy and resilience.[22] Psychological therapies that increase self-efficacy and performance are essential. Goal-setting, positive feedback, mental skills training, and other ways can boost an athlete's mental resilience and performance. Accepting these ideas explains how physiological and psychological factors affect athletes' mental energy. The findings suggest insulin resistance may directly impair mental energy, but athletic performance can mitigate this. Though insulin resistance affects cognition, positive performance perception may help athletes stay focused. This connection suggests that metabolic and psychological factors must be controlled to improve athletic performance and well-being. Athletic coaches, trainers, and healthcare providers can use this research. By enhancing metabolic health through diet and medicine and psychological well-being through mental skills training and positive reinforcement, athletes can enhance mental energy and performance. This integrated approach to athlete health highlights physiological and psychological aspects in training and recuperation.

The third hypothesis that perceived performance greatly influences insulin resistance and athlete mental energy illuminates the complex link between metabolic health and sports psychology. Thus, insulin resistance's lower glucose metabolism and cognitive weariness directly affect mental energy, however the athlete's perceived performance might greatly affect this. Positive performance views reduce insulin resistance by boosting mental energy and resilience. Self-efficacy and flow theories suggest confident, immersed athletes can better handle physiological stress.[16] Thus, goal-setting, constructive feedback, and mental skills training can improve performance judgements and lessen insulin resistance's cognitive effects. This strategy improves mental health, athletic performance, and well-being. Accepting the fourth hypothesis, which states that athlete burnout significantly moderates the insulin resistance-athlete mental energy relationship, reveals how physiological and psychological factors affect cognition. Burnout, marked by emotional exhaustion and a decreased sense of accomplishment, enhances insulin resistance's mental energy effects. Burnout may impair athletes' ability to handle insulin resistance-induced cognitive strain, resulting in mental tiredness and lower cognitive function. The stress-buffering hypothesis suggests that psychological resilience can reduce physiological stress to moderate burnout.[12] Burnout reduces resilience, worsening insulin resistance. Support systems like rest, psychological counselling, and balanced training programmes help prevent burnout and sustain mental vitality and athletic performance. These concepts support an integrated metabolic and psychological approach to athlete health. The findings show that controlling insulin resistance requires both physiological interventions like food and medication and psychological resilience like positive performance beliefs and burnout prevention. This research can be used to create psychological skills training programmes, provide athletes with regular psychological assistance, and create burnout-prevention recovery regimens. An atmosphere that supports metabolic and psychological wellness can boost mental energy and performance in athletes. This holistic approach recognises the complexity of sports health and emphasises the need to integrate physiological and psychological elements when developing tactics to improve performance and well-being.

Confirming all four hypotheses, it became clear how closely an athlete's cognitive performance, psychological mood, and metabolic condition interact. This study claims that insulin resistance reduces cognitive vitality; perceived performance significantly influences the association and athlete burnout somewhat affects it. These results underscore the requirement of dual-oriented athletic training and recovery. This method should give equal priority to psychological resilience and metabolic control if one wants the best outcomes. Cognitive vitality and physical performance can be raised by nutrition, medical treatment, mental skills development, and avoidance of burnout. Not only in sports but also in any demanding environment with metabolic and psychological pressures these findings can enhance performance and health. These results have implications beyond only certain sports. This all-encompassing approach reassessed athlete care and stresses the equal role of the mind and the body in performance.

Conclusion

In summary, this research has illuminated the complex relationships between insulin resistance, perceived performance, athlete burnout, and athlete mental energy in sports psychology and physiology. The findings show that metabolic health affects cognitive and emotional states, which are crucial for sports performance. They also stress the importance of holistic athlete care that includes physiological and psychological factors. Additionally, the identification of perceived performance as an intermediate and athlete burnout as a regulator has practical implications for improving athletes' mental fortitude and performance. Practitioners can use these data to create customised interventions to improve metabolic health, psychological well-being, and athlete performance. Research on longitudinal studies, mechanistic studies, and wider contextual factors is essential to improving techniques that promote athletes' holistic development and competitive sports performance.

Implications, Limitations and Future Research Directions

This research sheds light on the complex relationship between physiological and psychological aspects in athletic performance and well-being. The findings emphasise the relevance of including metabolic health in sports psychology. This study shows how physiological variables can directly affect cognitive and emotional states necessary for athletic performance by showing that insulin resistance dramatically impacts athlete mental energy. This integration contradicts traditional views that prioritise psychological therapies alone, proposing that optimising athlete health and performance requires a complete approach that addresses metabolic and psychological aspects. Second, sports psychology theories of self-efficacy and motivation benefit from the discovery that perceived performance mediates and moderates the association between insulin resistance, athlete burnout, and mental energy. The mediation effect reveals that athletes' performance perceptions facilitate cognitive mechanisms that link physiological measures to mental energy. This discovery illuminates how players perceive and respond to their physical environments and emphasises the importance of subjective judgements in athletic success. Athlete burnout moderation emphasises psychological resilience and stress management in athlete care regimens with physiological health exams. Modern athlete development models offer total physical and mental health assistance to increase well-being and performance sustainability.

This discovery affects athlete management, training, and healthcare. First, insulin resistance's considerable impact on athlete mental energy highlights metabolic diagnostics and sports-specific diets. Managing insulin sensitivity during training and competition may reduce cognitive fatigue and increase mental resilience. Early metabolic health management helps athletes perform at their best and promotes long-term health. Perceived performance and athlete fatigue underline the need for individualised psychological support in sports. Sports psychologists, coaches, and healthcare experts can use these findings to boost athletes' self-esteem and minimise burnout. Mindfulness, cognitive-behavioral therapy, and performance feedback help athletes stay mentally healthy. These findings promote resilience and sustained performance trajectories in athlete development programmes, boosting athletic outcomes and well-being.

This research has limitations despite its contributions. First, the study's self-reported measures of perceived performance and athlete burnout may introduce social desirability and subjective interpretation biases. Objective assessments or multi-method techniques could improve validity and reliability in future investigations. Second, cross-sectional data makes causality inferences difficult. This research discovered temporal connections and causal pathways that could be strengthened by longitudinal or experimental studies. The sample size and demographic homogeneity of participants may limit generalizability to other athletes. Future study should replicate these findings across multiple athlete groups to improve external validity and applicability across sports and competitive levels.

Based on this work, future research could explore new ways to better understand the complex interactions between insulin resistance, perceived performance, athlete tiredness, and mental energy in athletes. Initial research on insulin resistance and mental energy may identify physiological pathways and biomarkers. Neurobiological correlations of metabolic interventions on athlete cognition and mental resilience may be investigated. Second, insulin resistance and mental energy could be tracked to assess athlete burnout's dynamics. This research may uncover athletic burnout risk factors and time dynamics, improving prevention and assistance. Training intensity, rest, and food may reveal how insulin resistance affects athlete mental energy. Advanced statistical methods like structural equation modelling and latent growth curve analysis may explain the complicated relationship between physiological and psychological variables in athlete well-being and performance. Finally, studying coaching methods, team relationships, and competitive pressures may help researchers understand athlete mental health and performance. These methods may provide practical advice and evidence-based recommendations to improve sports athlete health, performance, and well-being.

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Appendix 1

Insulin Resistance

1. I am afraid of the pain when injecting insulin.
2. Besides the pain, I am just afraid of injections.
3. I am afraid of the pain during regular blood-sugar checks.
4. Insulin works better than pills.
5. People who get insulin feel better.
6. Insulin can reliably prevent long-term complications due to diabetes.
7. I just don't have enough time for regular doses of insulin.
8. I can't pay as close attention to my diet as insulin treatment requires.
9. I can't organize my day as carefully as insulin treatment requires.
10. Injections in public are embarrassing to me. Pills are more discreet.
11. Regular insulin treatment causes feelings of dependence.
12. When people inject insulin, it makes them feel like drug addicts.
13. An insulin overdose can lead to extremely low blood glucose levels (hypoglycemia). I am afraid of the unpleasant accompanying symptoms.
14. An insulin overdose can lead to extremely low blood glucose levels (hypoglycemia). I have concerns about possible permanent damage to my health.

Perceived Performance

1. I consider my performance is being good.
2. I am satisfied with my results in the competition.
3. I feel that I am collaborating with my effort and my performances in competition to improve the competitive level of the club or the team.
4. I feel like I'm doing very well in the competition.
5. I am offering good performance.

Athlete Burnout

1. I am accomplishing many worthwhile things in my sport
2. I feel so tired from my training that I have trouble finding energy to do other things
3. The effort I spend in my sport would be better spent doing other things
4. I am not achieving much in my sport
5. I feel overly tired from my sport participation
6. I don't care about my sport performance as much as I used to
7. I am not performing up to my ability in my sport
8. I feel "wiped out" from my sport
9. I am not into my sport like I used to be
10. I feel physically wom out from my sport
11. I feel less concerned about being successful in my sport than I used to
12. I am exhausted by the mental and physical demands on my sport
13. It seems that no matter what I do, I don't perform as well as I should
14. I feel successful at my sport
15. I have negative feelings toward my sport

Athlete Mental Energy

1. I feel spiritual to do everything in sports
2. I feel there is endless energy coming from my body
3. I feel I can win all the competitions in the future
4. I feel excited in future competitions
5. There's nothing distracting me in competition
6. There's nothing distracting me in training
7. No matter how long the training lasts I don't feel tired
8. I am full of passion to attend my sports
9. I can have my sports movements and skills automatically executed in sports
10. I am free of distraction during competition and training
11. Even the competition is over I still feel I have endless energy to use
12. Even the training is over I still feel I have endless energy to use
13. I can control all sports movements and skills
14. When facing to my opponents I am calm
15. Either in competition or training, I feel full of energy
16. I want to show my best to others in sports
17. Facing coming competitions I don't feel anxious
18. Even facing a tough opponent I don't feel anxious