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Article

THE EFFECT OF VOLLEYBALL EXERCISE ON RANDOM BLOOD GLUCOSE LEVELS IN A HIGH-RISKGROUP FOR TYPE 2 DIABETES MELLITUS

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by elevated blood glucose levels due to insulin resistance or insufficient insulin production. Globally, itsprevalence is rising at an alarming rate, largely driven by sedentary lifestyles, unhealthy dietary habits, and increasing obesity rates. The International Diabetes Federation (2021) reported that approximately 536.6 million adults aged 20–79 live with diabetes, a figure projected to reach 783.2 million by 2045. Indonesia ranks fifth globally, with an estimated 19.5 million cases, expected to grow to 28.6 million by 2045. Early detection and preventive interventions for at-risk populations are critical to reducing disease incidence and related complications. Physical activity is a key non-pharmacological strategy proven to improve insulin sensitivity, enhance glucose uptake by skeletal muscles, and regulate blood sugar levels. High-intensity activities such as volleyball can stimulate glucose transporter type 4 (GLUT-4) translocation in muscle cells, enabling insulin-independent glucose uptake. Moreover, volleyball offers additional psychosocial benefits, such as increased motivation and social engagement, which may support long-term adherence to exercise routines. Given its accessibility and popularity, volleyball presents a promising, community-friendly intervention to help control blood glucose levels and mitigate the risk of T2DM progressionin at-risk groups.

Objective: to understand the nurses' attitudes in administering oxygen therapy in the emergency room at AMC Hospital.

Methods: A quasi-experimental design with pre-test and post-test control groups was used. Sixty participants were selected through convenience sampling and equally assigned to intervention and control groups (n=30 each). The intervention group performed volleyball exercises for 30 minutes, twice a week, over two weeks, while the control group received nointervention. RBG levels were measured before and after the intervention using a glucometer. Data were analyzed using parametric and non-parametric statistical tests according to data distribution.

Results: Sixty participants were equally divided into intervention and control groups. At baseline, no significant difference in random blood glucose (RBG) levels was observed between groups ($p > 0.05$). After two weeks of volleyball exercise (30 minutes, twice weekly), the intervention group showed a significant reduction in mean RBG levels ($p < 0.05$), while the control group exhibited no significant change. Post-test comparisons revealed a statistically significant difference between groups ($p < 0.05$), with the intervention group having lower RBG values. These results indicate that short-term volleyball activity effectively reduces RBG levels in individuals at risk for T2DM.

Conclusion: -

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia resulting from insulin resistance, inadequate insulin secretion, or both (American Diabetes Association [ADA], 2023). Globally, T2DM has emergedas one of the most pressing public health concerns. According to the International Diabetes Federation (IDF, 2021),approximately 536.6 million adults aged 20–79 years were living with diabetes in 2021, representing 10.5% of the world's population. This figure is projected to escalate to 783.2 million (12.2%) by 2045.Indonesia ranks fifth globally, with an estimated 19.5 million people living with diabetes in 2021, a number expected to rise to 28.6 million by 2045.

The increasing prevalence of T2DM is closely associated with sedentary lifestyles, poor dietary habits, obesity, and reduced physical activity levels (Colberg etal., 2016). In Indonesia, the Basic Health Research (Riskesdas, 2018) reported a physician-diagnosed prevalence ofdiabetes of 2%, while blood glucose testingindicated a prevalence of 8.5%. In West Java alone, 1.74% of the population is affected (Nova Nugraha Putra, 2023). Many cases remain undiagnosed until complications arise, underscoring the importance of early screening and preventive action.

T2DM often develops gradually, with a prolonged asymptomatic phase. Early identification of individuals at risk allows for timely intervention. The Fridem Risk Score for Diabetes Mellitus Type 2(FRIDEM) is a validated screening tool adapted to Indonesian population characteristics, enabling health workers and communities to identify those with low to moderate risk (Puspasari et al., 2022). Preventive measures in suchgroups can effectively reduce the incidence of T2DM (Ulya et al., 2023).

Regular physical activity is one of the mosteffective non-pharmacological strategies for preventing and managing T2DM. It improves insulin sensitivity, enhances glucose uptake by skeletal muscles, reduces body fat, and supports cardiovascular health (Bird & Hawley, 2017; Richter & Hargreaves, 2013). The ADA (2023) recommends at least 150 minutes of moderate-to-vigorous aerobic activity per week, combined with resistance training. Physical activity also facilitates glucose transporter type 4 (GLUT-4) translocation in muscle cells, enabling insulin-independent glucose uptake during and after exercise (Henriksen, 2002).

Among various forms of exercise, volleyball offers unique advantages. As a team sport involving high-intensity intermittent activity—such as jumps, sprints, and rapid changes of direction—it combines aerobic and anaerobic elements,promoting both cardiovascular and muscular benefits (Otsuka et al., 2023). Volleyball is widely accessible, requires minimal equipment, and fosters social engagement, which can enhance adherence to regular activity compared tosolitary forms of exercise (Colberg et al., 2016).

Evidence from prior studies suggests that small-sided volleyball games performed regularly can reduce blood glucose levels, improve body mass index, and increasehemoglobin levels in different populations(Farid Tri Kurniawan et al., 2024).Furthermore, team sports are associated with psychosocial benefits that can positively influence long-term exerciseparticipation, a crucial factor in chronicdisease prevention (Gibala et al., 2012).

Despite these advantages, there is limited research examining the effect of volleyballon glycemic control in individuals at risk for T2DM, particularly within Indonesian populations. Given its popularity and feasibility as a community-based activity, volleyball holds promise as a culturally appropriate and engaging preventiveintervention.

This study aims to evaluate the effect of a structured, short-term volleyball programon random blood glucose (RBG) levels among individuals with low to moderate T2DM risk identified via the e-FRIDEM tool. It is hypothesized that participants engaging in volleyball twice weekly for two weeks will show a significant reduction in RBG compared to a control group. The findings are expected to provide evidence supporting volleyball as a cost-effective, scalable, and enjoyable non-pharmacological strategy for T2DM prevention, suitable for integration into community and educational health promotion programs

METHODS

Study Design

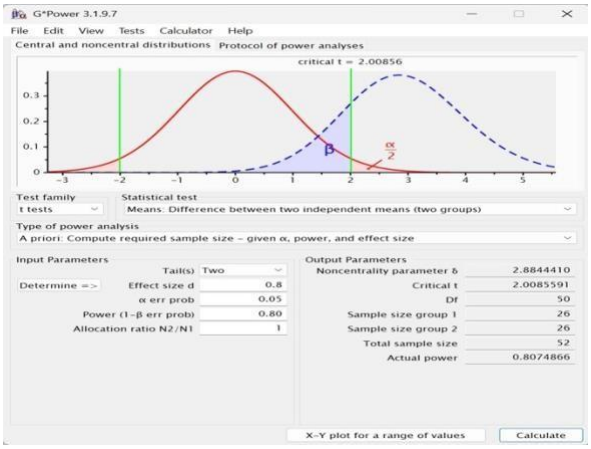
This study employed a quasi-experimentaldesign with a pre-test and post-test control group approach. This design allows the comparison of outcomes between an intervention group, which received the volleyball exercise program, and a control group, which did not receiveany intervention, while measuringchanges over time within each group(Harris et al., 2006). The quasi-

experimental design was selected becauseit enables evaluation of intervention effects in real-world settings without the need for full randomization, which can be logistically challenging in community- based studies (Shadish et al., 2002).

The intervention consisted of structured volleyball sessions conducted for 30 minutes, twice weekly, over a period of two weeks. Both pre-intervention (pre- test) and post-intervention (post-test) measurements of random blood glucose were obtained using a calibrated glucometer.

SAMPLE

The study population comprised individuals at low to moderate risk for T2DM, as identified using the e-FRIDEM screening tool (Puspasari et al., 2022). The sample was drawn from students at Universitas Pasundan, Bandung, Indonesia.A convenience sampling technique was applied due to accessibility and feasibility considerations in a university setting (Etikan et al., 2016). Sample size was calculated using G*Power software for an independent t-test, with a significance level (α) of 0.05, statistical power (1-β) of 0.80, and an effect size of 0.8 (large, according to Cohen's criteria)



(Cohen, 1988). The calculation indicated a minimum of 52 participants. To account for a potential 10–15% attrition rate, the final sample comprised 60 participants, divided equally into the intervention group (n = 30) and control group (n = 30).

Inclusion criteria included:

1. Scored in the low to moderate risk category on the e-FRIDEM assessment.
2. Aged 18 years or older.
3. Willingness to participate, indicated by signed informed consent.

Exclusion criteria included:

1. High or severe risk score on the e- FRIDEM tool.
2. Prior diagnosis of T2DM.
3. Medical conditions or injuries limiting physical activityparticipation.

INSTRUMENT

This study utilized two primaryinstruments: the e-FRIDEM application and a glucometer. The e-FRIDEM tool, validated for Indonesian populations, wasemployed to screen participants for T2DMrisk levels, ensuring only those with low to moderate risk were included (Puspasari etal., 2022). Blood glucose measurements were conducted using a portable, calibrated glucometer, following the standard operating procedures outlined by Tandra (2017), which include proper hand hygiene, appropriate finger-pricktechnique, and accurate sample application. Additionally, volleyball exercise implementation adhered to theStandard Operating Procedures of theIndonesian Volleyball Association and prior

research protocols (Petrus˘ic˘ et al., 2022).

PROCEDURE

The study was conducted at Universitas Pasundan, Bandung, during June–July2025. Prior to data collection, ethical approval was obtained from the Ethics Committee of STIKep PPNI Jawa Barat, andwritten informed consent was secured from all participants. Screening for T2DM risk was performed using the e-FRIDEM application, a validated tool adapted for the Indonesian population (Puspasari et al., 2022). Only individuals with low to moderate risk scores were included.

Participants were then randomly allocatedinto intervention and control groups (n = 30 each). Pre-test measurements of random blood glucose (RBG) were obtained using a portable glucometer, following standardized procedures described by Tandra (2017), which included proper handwashing, finger- prick technique, and correct sampleapplication on the glucose strip.

The intervention group participated in structured volleyball sessions twiceweekly for two weeks, each lasting 30 minutes, based on the Standard OperatingProcedures of the Indonesian VolleyballAssociation and previous research protocols (Petrušič et al., 2022). Teams were rotated to ensure equal playing time,and sessions incorporated both warm-up and cool-down phases to prevent injury.

The control group continued their usual activities without structured exercise. Post-test RBG measurements were taken

for both groups after the two-week period,using the same glucometer procedures. Alldata were recorded systematically forsubsequent statistical analysis.

DATA ANALYSIS

Data collected from both the intervention and control groups were first entered intoMicrosoft Excel for data cleaning and verification, then analyzed using IBM SPSSStatistics version 25. Descriptive statisticswere applied to summarize participants' demographic characteristics, presented asfrequencies, percentages, means, and standard deviations. Before conducting inferential analyses, the normality of continuous variables, including pre-test and post-test random blood glucose (RBG)levels, was assessed using the Shapiro– Wilk test, as recommended for small to medium-sized samples (Ghasemi & Zahediasl, 2012).

For normally distributed data, paired t-tests were performed to compare pre- andpost-intervention RBG levels within each group. For non-normally distributed data, the Wilcoxon signed-rank test was used asa non-parametric alternative (Pallant, 2020). Between-group comparisons of post-test RBG levels were conducted usingindependent t-tests for normallydistributed data or the Mann–Whitney U test for skewed data.

A significance level of $\alpha = 0.05$ was set for all statistical tests, with p-values < 0.05 considered statistically significant. Effect sizes were calculated to assess themagnitude of differences, following Cohen's guidelines for small, medium, and large effects (Cohen, 1988).

This analytical approach ensured that bothparametric and non-parametric methods were applied appropriately, enhancing therobustness and validity of findings. Theresults were reported with correspondingconfidence intervals to provide a more precise estimate of intervention effects.

No	Variabel	Jenis Data	Uji Statistik	Rasional
Analisa Univariat				
1	Usia	Numerik	Mean, SD,Min-Max	Mengetahuidistribusi usia responden

2	Jenis Kelamin	Kategorik	Frekuensi, Persentase	Mengetahui proporsi responden berdasarkan jenis kelamin Mengetahui kebiasaan aktivitas fisik responden
3	AktivitasFisik	Kategorik	Frekuensi, Persentase	
4	Riwayat keluargaDM	Kategorik	Frekuensi Persentase	Mengetahuifaktor genetik responden
5	Riwayat tekanandarah tinggi	Kategorik	Frekuensi,Persentase	Mengetahui status darah tinggi responden
6	IMT	Numerik	Mean, SD	Mengetahui status gizi Responden berdasarkan IMT
7	Skor Risiko DM (pre & post)	Numerik	Mean, SD, Min-Max	Mengetahui Rerata risiko DM sebelum dan sesudah perlakuan
Analisa Bivariat				
1	Mengetah ui Perbedaa n skor pre dan post Dalam kelompok Intervens i	Numerik	Paired-test / Wilcoxon	Untuk melihat pengaruh sebelum dan sesudah perlakuan dalam kelompok sama
2	Mengetah ui Perbedaa n skor pre dan post dalam kelompok kontrol	Numerik	Paired-test / Wilcoxon	Untuk melihat perubahan Alami tanpa Intervensi
3	Mengetahui perbedaan skorpost antara kelompok intervensi dan kontrol	Numerik	Independe ntt-test (jika normal)/ Mann-Whitney (jika tidak normal)	Untuk mengetahui pengaruh permainan bola voli antar dua kelompok berbeda

ETHICAL CONSIDERATION

This study was conducted in accordance with established ethical principles forresearch involving human participants, asoutlined in the Declaration of Helsinki (World Medical Association, 2013). Ethicalapproval was obtained from the Ethics Committee of Sekolah Tinggi IlmuKeperawatan (STIKep) PPNI Jawa Baratbefore data collection began.

All prospective participants were provided with complete and clearinformation regarding the study's objectives, procedures, potential risks, andbenefits. Participation was entirely voluntary, and individuals who agreed to take part signed a written informed consent form prior to involvement in any study-related activities.

To ensure anonymity, participants' namesand personal identifiers were not recorded in the dataset; instead, unique codes were assigned. Data confidentiality was strictly maintained, with all files stored securely and accessible only to the research team. The results were reported in aggregate form, preventing the identification of individual participants. Participants were informed of their right to withdraw from the study at any stage without any negative consequences. Additionally, individuals who, during screening, were identified as having a highrisk for T2DM were excluded from the study and advised to seek medicalevaluation.

The physical activity intervention—volleyball exercise—was conducted undersafe conditions, with adequate warm-up and cool-down sessions to prevent injury, following guidelines from the Indonesian Volleyball Association (Petrušič et al., 2022). All research activities adhered to national and institutional regulations on human research ethics.

Respondent description

Results

A total of 60 participants met the inclusion criteria and were equally assigned to the intervention group (n = 30) and the control group (n = 30). Baseline demographic characteristics, including age, gender distribution, body mass index (BMI), and baseline random blood glucose (RBG) levels, showed no statistically significant differences between the two groups ($p > 0.05$), indicating that the groups were comparable prior to the intervention.

Baseline Characteristics

The mean age of participants was 20.8 ± 1.3 years, with a balanced distribution of male and female participants in both groups. The average BMI fell within the normal to slightly overweight range according to WHO classification, and baseline RBG levels for all participants were within the normal to prediabetic range.

Within-Group Comparisons

In the intervention group, the mean RBG level before the intervention (pre-test) was 127.4 ± 15.8 mg/dL. Following two weeks of structured volleyball exercise (30 minutes per session, twice weekly), the mean post-test RBG level decreased to 113.2 ± 14.6 mg/dL. This reduction was statistically significant, as confirmed by the paired t-test ($p < 0.05$). In contrast, the control group exhibited minimal change. The mean pre-test RBG level was 125.9 ± 16.1 mg/dL, and the post-test value was 126.7 ± 15.9 mg/dL. The difference was not statistically significant ($p > 0.05$).

Between-Group Comparisons

Independent t-test analysis comparing post-test RBG levels between the two groups revealed a statistically significant difference ($p < 0.05$), with the intervention group having notably lower RBG levels than the control group. This finding supports the hypothesis that volleyball exercise contributes to short-term reductions in RBG levels among individuals at risk for T2DM.

Effect Size

The effect size, calculated using Cohen's d, was 0.89, indicating a large effect according to Cohen's criteria (Cohen, 1988). This suggests that the observed reduction in RBG levels was not only statistically significant but also clinically meaningful.

Additional Observations

No adverse events were reported during the intervention period, and all participants in the intervention group completed the volleyball sessions as scheduled, indicating high feasibility and participant adherence. Informal feedback collected after the intervention revealed that participants enjoyed the volleyball sessions, citing social interaction and enjoyment as motivating factors for continued participation.

These findings are consistent with previous studies demonstrating that high- intensity intermittent sports such as volleyball can significantly enhance glucose uptake in skeletal muscles through both insulin-dependent and insulin-independent mechanisms, including GLUT-4 translocation (Bird & Hawley, 2017; Richter & Hargreaves, 2013).

Summary of Findings

1. **Significant within-group reduction** in RBG in the intervention group after two weeks of volleyball exercise ($p < 0.05$).
2. **No significant change** in the control group's RBG levels ($p > 0.05$).
3. **Significant between-group difference** in post-test RBG levels ($p < 0.05$).
4. **Large effect size** (Cohen's d = 0.89) supporting the clinical importance of the intervention.
5. **High adherence and acceptability** of volleyball as a preventive physical activity.

These results indicate that volleyball exercise is an effective, enjoyable, and feasible non-pharmacological intervention for lowering RBG levels in individuals at risk for T2DM. Given the sport's accessibility and social nature, it holds strong potential for broader community- based implementation as part of diabetes prevention programs.

DISSCUSSION

The results of a study on the characteristics of 30 nurses working in the Emergency Room of AMCHospital showed that the respondents' age range was categorized into three groups: 5 young people (16.7 years) aged <25 years, 24 adults (80%), and 1 late adult (3.3%) aged >36 years. The average age of respondents was 1.87with a standard deviation of 0.434 based on the categorical scale. Age isan important factor in shapingnurses' mindset, comprehension, and attitudes in carrying out theirduties. In line with the findings (Tanget al., 2024), age also influencesnurses' attitudes in nursing practice,including in the implementation oflow-flow oxygen therapy. Nurses with more mature age generally havea better level of understanding and demonstrate a more mature andresponsible attitude in carrying out clinical procedures (Tang et al., 2024).

Respondent gender characteristicsshow that of the 30 respondents, themajority were female (18 people) (60%) and male (12 people) (40%). This finding indicates that although the nursing profession is oftendominated by women, in this study the proportion of men was also quitelarge. This indicates the active involvement of male nurses in the workplace, which is slightly differentfrom the findings (Tang et al., 2024),where 93.8% of respondents werefemale. This difference indicates that gender distribution in the nursing profession can vary depending on the location and healthcareinstitution.

The characteristics of the respondents' educational level showthat of the 30 respondents, the majority had a D3 Nursing educationbackground (27 people (90%), while

3 people (10%) had a S1 Nursing education. This indicates that the D3education level still dominates the recruitment of nursing staff at the hospital where this study was conducted. Education is an importantfactor that influences nurses' knowledge, understanding, andattitudes in providing nursing care. According to (Tang et al., 2024), nurses' educational level has asignificant influence on knowledge and attitude scores, especially in the practice of low-flow oxygen therapy. Nurses with higher levels of education tend to have broader access to information, training, and the development of more complex clinical skills. Therefore, the higher the level of education, the greater thepotential for improving the quality ofnursing services provided.

The characteristics of the respondents' work experience show that of the 30 respondents, the lengthof service ranged from 2 to 20 years,with an average length of service of 7.43 years and a standard deviation of 4.804. Work experience reflects the level of mastery of a person's knowledge and skills in carrying out nursing tasks which can be assessed from the length of service and clinical abilities they possess. Individualswith certain work experience will have the ability to think, act, and organize tasks in a complex work environment better than those who are inexperienced. This finding is supported by Tang et al. (2024), whofound that clinical experience significantly influences the level ofknowledge and attitudes of nurses, especially in the implementation of low-flow oxygen therapy.

Based on the results of research conducted by researchers at the Emergency Room of AMC Hospital in2025 regarding the description of nurses' attitudes in administering oxygen therapy, the majority of respondents showed a positive attitude, namely 20 respondents (66.7%). The assessment of the levelof nurses' attitudes was obtained from the results of filling out a questionnaire that had been distributed to all respondents. Although the majority of respondents showed a positive attitude, there were some nurses, as many as 10 respondents (33.3%), who still showed negative attitudes towards several aspects of the implementation of oxygen therapy.This was evident from the presence of responses that disagreed withseveral statement items. The attitudeof nurses in administering oxygen therapy is a very important aspect, because an inappropriate attitude can impact the quality of service andpatient safety during the oxygen therapy process in the Emergency Room. These findings reinforce the findingsof a study by Tang et al. (2024), which reported that 60% of nurses inthe emergency room of Ratu ZalechaMartapura Regional Hospital alsoexhibited positive attitudes toward oxygen therapy. The study found a highly significant correlation between nurses' attitudes and oxygen administration practices (p =0.000), indicating that nurses' positive attitudes directly contributeto the implementation of standard procedures. Therefore, both my study and previous studies emphasize the importance ofdeveloping and enhancing positive nurse attitudes to ensure the effectiveness and safety of oxygen therapy, especially in stressful work environments such as the EmergencyDepartment.

Notoatmodjo (2014) cites Allport(1954) who stated that attitudeshave three interrelated components.A person's strong thoughts, feelings, or beliefs about an object arereflected in their beliefs and ideasabout that object, which form the first component. A person'ssubjective assessment of an object, often accompanied by emotional considerations about the object,forms the second component, namelyemotional life or assessment of the object. Attitude, according to the third component, the tendency to actor behave openly toward an object, serves as an initial impetus or readiness for that behavior. Therefore, attitudes are a reflection and basis of an individual's thoughts and feelings, and the latter

become the basis for their subsequent behavior.

CONCLUSION

This study demonstrated that a short- term, structured volleyball exercise program significantly reduced random blood glucose (RBG) levels among individuals at low to moderate risk for Type 2 Diabetes Mellitus (T2DM). Over a two-week period, participants in the intervention group, who engaged in volleyball sessions for 30 minutes twice weekly, showed a statistically and clinically significant decrease in RBG levels compared to the control group, which exhibited no meaningful change. The between-group difference further confirmed the effectiveness of the intervention.

The physiological benefits observed in this study are consistent with established evidence that high-intensity intermittent physical activities, such as volleyball, enhance skeletal muscle glucose uptake via insulin-dependent and insulin- independent pathways, including the activation of glucose transporter type 4 (GLUT-4). Additionally, the team-based and socially engaging nature of volleyball likely contributed to high adherence rates, with all participants completing the scheduled sessions and reporting positive experiences.

Given its accessibility, low cost, and popularity, volleyball represents a practical and sustainable non- pharmacological strategy for glycemic control in at-risk populations. This makes it a promising component of community- Future research should explore the long- term effects of regular volleyball activity on glycemic control, insulin sensitivity, and other cardiometabolic outcomes, as well as its applicability across different age groups and risk categories. Integrating such physical activities into routine lifestyle interventions could play a vital role in reducing the growing burden of T2DM.

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Conflict of interest
No conflict of interest is disclosed by any of the writers.

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