Journal of Public Health and Pharmacy
2775-4952 (Online - Elektronik)
Research Articles Open Access

# The Sensitivity, Specificity and Cutoff of Physical Activity and Psychological Stress on Chronic Kidney Disease

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**ARTICLE INFO**

**Manuscript Received:** 21 July 2024
**Revised:** 27 Oct, 2024
**Accepted:** 09 Dec, 2024
**Date of publication:** 10 Feb, 2025
**Volume:** 5
**Issue:** 1
**DOI:** 10.56338/jphp.v5i1.5778

**KEYWORDS**

Chronic;
Kidney;
Physical Activity;
Stress

## ABSTRACT

**Introduction:** The prevalence of chronic kidney disease (CKD) in Kendari City, Southeast Sulawesi tends to increase. CKD is a Silent Killer disease, because sufferers do not realize it early. There are many risk factors for CKD, including low physical activity and psychological stress, but their effects on CKD unclears in Kendari City. The aim of study is to analyse level sensitivity, specificity and cutoff point of physical activity and psychological stress effect on CKD in Kendari City.
**Methods:** This study applied a quantitative method with cross sectional study recruited 136 people who aged 17-75 years old. They were interviewed with a questionnaire and took urine samples to determine proteinuria as a biomarker of CKD, using the 24-hour urinalysis method. Data analysis used the ROC curve at a 95% confidence interval ($p<0.05$) was considered statistically significant.
**Results:** This study found that physical activity had the ability to predict CKD by 68.6% (95%CI: 59.7%-77.5%). Meanwhile, the psychological stress variable has the ability to predict CKD is 76.1% (95% CI: 64.6%-87.7%). The sensitivity and specificity of physical activity are 62.9% and 63.6% respectively. The cut-off point of physical activity is 4.25 hours per day. Meanwhile, the sensitivity and specificity of psychological stress is 71.4% and 69.6% respectively. The Cutoff points for psychological stress is 12.50 or mild stress.
**Conclusion:** Physical activity and psychological stress variables can both be used to predict CKD in Kendari City. However, the ability of the psychological stress variable is slightly stronger than the physical activity variable. Someone who does physical activity equal to or above 4.25 hours per day is 62.9% less likely to suffer from kidney disease, compared to those whose physical activity is less than 4.25 hours per day. Thus, for someone who experiences mild psychological stress or above, they are 71.4% more likely to experience kidney disease, compared to those who are not stressed. The results of this study can contribute to the literature to determine program standards in carrying out health promotion and prevention towards controlling chronic kidney disease.

**Publisher**: Pusat Pengembangan Teknologi Informasi dan Jurnal Universitas Muhammadiyah Palu

## INTRODUCTION

Chronic Kidney Disease (CKD) is still a problem almost throughout the world, including in Southeast Sulawesi Province, Indonesia. The prevalence of CKD tends to continue to increase in Southeast Sulawesi Province. In 2022, the prevalence of CKD in Southeast Sulawesi Province increased in 0.23%, compared to 2013 in 0.2% (1,2). The prevalence of CKD in Southeast Sulawesi province is also relatively high when compared to the average in Indonesia, which is only around 0.18% (2). One area in Southeast Sulawesi Province where has a high prevalence of CKD is the Kendari City. In 2020, there were 473 CKD patients undergoing haemodialysis (3). The prevalence of CKD shows an increase compared to 2019, which was 157 people (4).

CKD is a "Silent Killer" disease. Individuals are always less aware of the emergence of chronic kidney disease until it enters the final stage (5–9). Several studies suggest that when people with hypertension and diabetes mellitus diseases are not treated properly, so they will experience complications in their kidney organs (10–13). In 2022, the prevalence of hypertension in Kendari City is 78.99% and 92.35% of Diabetes Miletus disease. This prevalence is very high when compared with the average in Southeast Sulawesi Province, namely 41.04% for hypertension and 64.48% for Diabetes Miletus (13). Other risk factors for chronic kidney disease are physical activity and psychological stress (14–19).

Currently, people in Kendari City have easy access to complete their daily needs, both at home and at work. Digital transformation makes people in Kendari City carry out communications and business transactions via smart phones easily, quickly and without physical activity. Smart phones, computers and the internet have become tools for meeting the daily needs of people in Kendari City. The phenomenon that occurs is the high level of sedentary behaviour in society. People do not have the opportunity to do adequate physical activity. In fact, physical activity can provide many benefits for the body, such as resistance to circulating C-reactive protein and interleukin-6, increased oxygen consumption (VO2), improved quality of life for CKD patients, and changes in glomerular filtration rate (14–16). This is one of the reasons why the prevalence of hypertension is high in Kendari City which leads to chronic kidney disease.

Besides that, the conditions in Kendari City also encourage high levels of psychological stress. In 2022, there will be around 83.08% or around 378 people suffering from mental disorders classified as severe (20). The previous study stated that psychological stress can interfere with kidney function through disturbances in brain function, the immune system, the cardiovascular system, the gastrointestinal system and endocrine system disorders (21). Several studies report that almost half of CKD sufferers are caused by psychological disorders (18,19,22–25). Stress in pregnant women can also affect the development of their child towards kidney disease (26).

However, empirical evidence regarding the effects of low physical activity and psychological stress is not yet clear, especially regarding the cutoff point of these factors that have an impact on impaired kidney function. How much physical activity and psychological stress can influence human kidney function is also not yet clearly known. At what level of sensitivity and specificity do physical activity and psychological stress factors interfere with kidney health? This also still needs to be analysed further. These empirical evidences can be a basis for formulating policies and programs to deal with chronic kidney disease in Kendari City. Therefore, this study analyses the level of sensitivity, specificity, and cutoff point of physical activity and psychological stress factors on chronic kidney disease in Kendari City. By obtaining empirical data regarding cut-off values, levels of sensitivity and specificity, it will provide guidance for developers of health policies and programs in carrying out health promotions towards preventing chronic kidney disease in Kendari City.

## METHOD

### Study Desain

This quantitative study used a Cross-Sectional Study approach. This study was carried out in the Lepo-Lepo, Mata, Abeli and Kandai Health Centre areas. And carried out at Bahteramas Hospital, Kendari City Hospital, and Santa Anna Hospital in Kendari City, Southeast Sulawesi Indonesia. This research will be carried out from June 2023 to August 2023.

### Population and Samples

The population in this study were people who were classified as healthy, had single diseases, multiple diseases, and chronic kidney disease patients. The sample recruited was 136 people, using the Accidental sampling

technique. The accidental sampling technique was chosen because the population is not known with certainty (27). The accidental sampling method is a research method that is quite economical and researchers have freedom of exploration in determining samples that they feel meet the requirements (28). To ensure that bias does not occur, researchers developed inclusion and exclusion criteria and sampling was stopped when there were 136 people. The inclusion criteria of the sampling were aged between 17-75 years old, and had lived in Kendari City for at least 2 years. Exclusion criteria were mothers who were pregnant, unable to communicate, unwilling to be respondents, and living in Kendari City for less than 2 years.

**Define all variables measured in the study**

The independent variables in this research are physical activity and psychological stress. Data on physical activity and psychological stress were obtained through interviews with questionnaires that had been tested for validity and reliability. The results of the validity test obtained a Corrected item Total Correlation value for physical activity of 0.650 and psychological stress of 0.677. Instruments These two variables are declared valid because they are above the r table value of 0.168 (df = 134, 5%).

Based on the statistical reliability test, the Cronbach's Alpha value for physical activity was 0.640 and the Cronbach's Alpha value for psychological stress was 0.646. The two r values are declared reliable because the r value is above the r table value, namely 0.361 (n=136 and 5%).

Physical activity variable is calculated in hours per day and the data type is a ratio. The psychological stress variable is calculated based on the symptoms felt and the total scores are grouped into 5 categories, namely Normal (score ≤11); mild stress (score 12 - ≤22); moderate stress (score 23 - ≤32); severe stress (score 33 - 43); and very severe stress (score ≥44).

The dependent variable of this study is urine protein level as a biomarker of CKD (29). Urine Protein data was collected by taking 30-60 ml, with the 24-hour urine examination method and using the dip stick with Urine Reagent Strips "URIT 13G". Examination of protein levels is also carried out macroscopically. The principle of protein examination using URIT 13G is the test is based on the principle of the protein error of a pH indicator. The reagent area is more sensitive to albumin. An elevated pH up to 9 may affect the test. The residues of disinfectants containing quaternary ammonium group or chlorhexidine are present in the urine vessel maybe led to a false positive result. The protein level for CKD using URIT 13G is determined by the following colour:

**Table 1**. Urine Protein Level Categories

| | **Urine Protein level categories*** | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Color | | | | | |
| Urine protein levels (g/L) | -(0) | ± | +(0.3) | ++(1.0) | +++(≥3.0) |

*(30)

**Data analysis and interpretation**

Data analysis used the ROC (Receiver Operating Characteristic) curve with a confidence level of 95% (alpha=0.05). Data analysis with ROC curve used SPSS software version 25.0. The ROC curve is a graphical plot that depicts the diagnostic ability of a binary classifier system as its discrimination threshold is varied (31). The ROC curve is a plot of the values of sensitivity vs 1-specificity as the value of the cutoff points moves from 0 to 1. Sensitivity is the probability that the model predicts a positive outcome for an observation when indeed the outcome is positive. The specificity is the probability that the model predicts a negative outcome for an observation when indeed the outcome is negative. A Roc curve is one easy way to visualize the two metrics of a logistic regression model.

Sensitivity in this study is defined by the ability of physical activity and stress factors to indicate which individuals suffer from chronic kidney disease from the entire population who actually have chronic kidney disease. Meanwhile, specificity is defined by the ability of physical activity and stress factors to indicate which individuals do not suffer from chronic kidney disease from those who really do not have chronic kidney disease.

ROC curve analysis with SPSS version 25.0 provides an information table about the Area Under the Curve (AUC) which explains the ability of physical activity and psychological stress variables to predict chronic kidney disease. The AUC describes the model of influence between positive and negative results. The AUC can range from 0 to 1. The higher the AUC, the better the model is at correctly classifying outcomes. In detail, the interpretation of the AUC value is as follows; AUC of > 0.9-1 is Excellent; AUC of >0.8-0.9 is Very good; AUC of >0.7-0.8 is Good; AUC of >0.6-0.7 is Moderate; and AUC of 0.5-0.6 is Not Good.

ROC curve analysis also provides a table about the Coordinated of the curve which provides an illustration of the cut-off points of physical activity and psychological stress variables on sensitivity and 1-specificity. To get cut-off values for physical activity variables and psychological stress variables, use the Tangent graph. The tangent graph is based on the results of calculations between sensitivity and specificity values (32). The specificity value is obtained by subtracting from 1–the specificity value. Then a cross-sectional graph between the sensitivity and specificity values is created. The cross-sectional point of the tangent graph shows the line of sensitivity and 1-specificity values, which is the basis for determining the cut-off point for the influence of physical activity variables and psychological stress variables on chronic kidney disease.

### Ethical considerations

Ethical approval was carried out for this study which was conducted at Ethical committee of Mandala Waluya University with number 023/KEP/UMW/VI/2023 on June 19th, 2023.

## RESULTS

### Participant Characteristics

Participants in this study were 136 people with an average age of 48 ± 12 (table-2). The majority of participants were in the 51–60-year group (30.1%), while the smallest group was 36–40-year-olds (9.6%). In the healthy group, the majority of ages are less than 35 years. Meanwhile, in the single and multiple disease groups, most were aged 51-60 years. The largest group of CKD sufferers is aged 41-50 years.

Most participants' education was high school (33.8%), and the smallest were doctoral degrees (0.7%) and no school (2.2%). There were also many participants who had degrees after high school, namely 28.7%. Half of the participants were unemployed (50%). However, there are those who work in the government (21.3%) and the private sector (13.2%).

**Table 2.** Participant's Characteristics

| Age (Years) | Total | % Total | Education | | | Occupation | | |
|---|---|---|---|---|---|---|---|---|
| < 35 | 24 | 17.6 | Not completed on primary school | 3 | 2.2 | No Work | 68 | 50.0 |
| 36-40 | 13 | 9.6 | Primary school | 18 | 13.2 | Labourer | 3 | 2.2 |
| 41-50 | 37 | 27.2 | Yunior High school | 18 | 13.2 | Farmer | 5 | 3.7 |
| 51-60 | 41 | 30.1 | Senior HS | 46 | 33.8 | Self-employed | 13 | 9.6 |
| >60 | 21 | 15.4 | diploma | 4 | 2.9 | Private/ BUMN | 18 | 13.2 |
| | | | Bachelor | 39 | 28.7 | Civil Servants | 29 | 21.3 |
| Mean ± SD | 48 ± 12 | | Master | 7 | 5.1 | | | |
| Total | 136 | 100.0 | | 136 | 100.0 | | 136 | 100.0 |

### Sensitivity, Specificity and Cut-off of Physical Activity Effect on CKD

The Roc curve analysis below shows that physical activity in the moderate category predicts chronic kidney disease in Kendari City. The ROC Curve shows an AUC of physical activity to predict people with chronic kidney diseases is 68.6% with a 95% confidence interval of 59.7% - 77.5% (Table 3). This means that there are other factors besides physical activity that influence CKD, namely 31.4%.

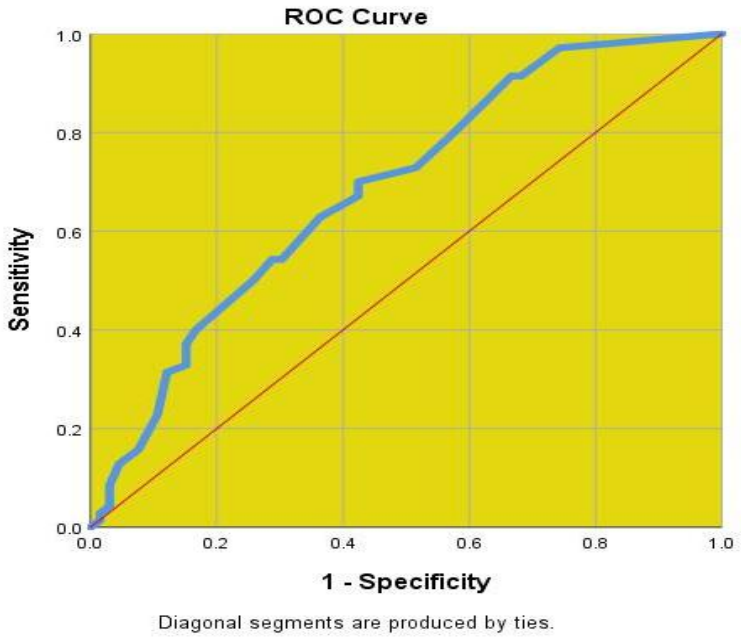


**Figure 1.** Sensitivity and Specificity of Physical Activity Effect on Chronic Kidney Disease in Kendari City

The number of individuals who do good physical activity and do not suffer from CKD is 70 people. Meanwhile, the number of individuals who lack of physical activity and suffer from CKD is 66 people (Table 3). This means that individuals who do enough physical activity in a day have a high chance of not suffering from chronic kidney disease. On the other hand, individuals who do less physical activity are more likely to suffer from chronic kidney disease.

**Table 3.** Area Under the Curve of Physical Activity

| Area (AUC) | Std. Error[a] | Asymptotic Sig.[b] | Asymptotic 95% Confidence Interval | | Positive[C] | Negative |
|---|---|---|---|---|---|---|
| | | | Lower Bound | Upper Bound | | |
| 0.686 | 0.045 | 0.000 | 0.597 | 0.775 | 70 | 66 |

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

c. The positive actual state is 0

The cut-off point for physical activity as a warning limit for chronic kidney disease is shown in the cross-sectional graph below, which is generated from the sensitivity and specificity values for physical activity in chronic kidney disease in Kendari City (Figure 2).

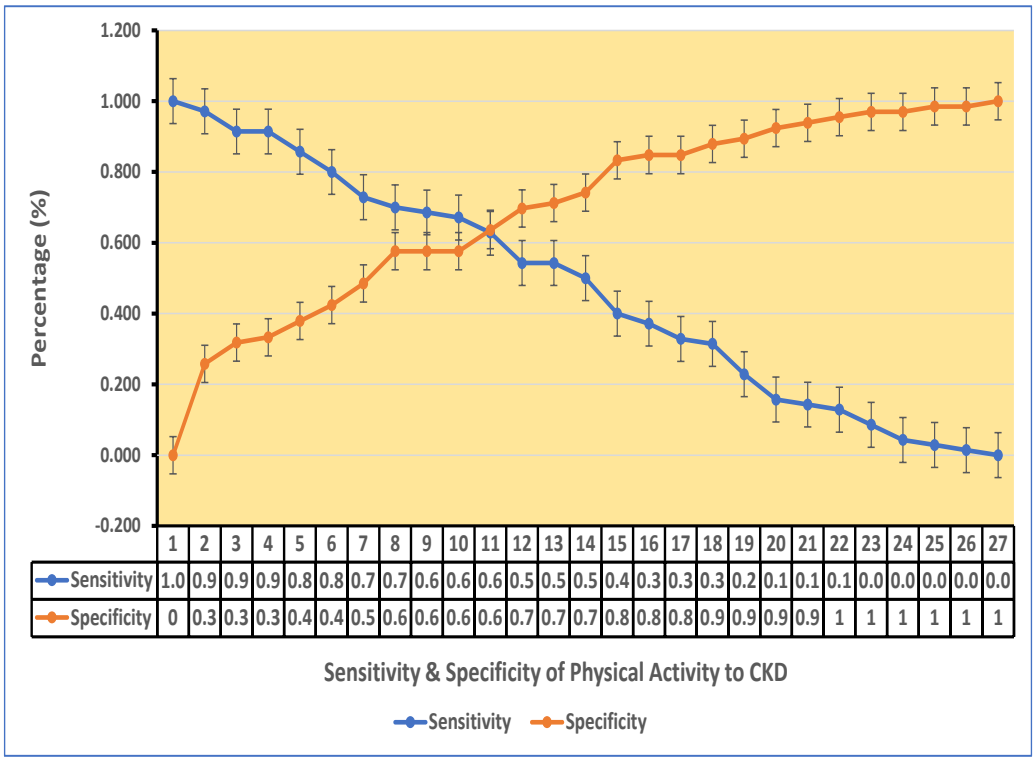


**Figure 2.** The Cut-off point of physical activity effect on CKD in Kendari City

The graph above shows the intersection point between the sensitivity and specificity values at number 11 with a sensitivity value of 0.629 (62.9%) and a specificity of 0.636 (63.6%) (table-4). Based on the test result variable: positive if greater than or Equal to at that level shows a value of 4.25. This value means that the cutoff point for physical activity for chronic kidney disease is 4.25 hours a day. This cut-off point means that if an individual's physical activity is equal to or above 4.25 hours per day, there is a 62.9% chance that they will not suffer from chronic kidney disease. However, if an individual's physical activity is less than 4.25 hours per day, there is a 63.6% chance of suffering from chronic kidney disease.

**Table 4.** Coordinates of the Curve of Physical Activity

| No | Positive if Greater Than or Equal To* | Sensitivity | 1 - Specificity | Specificity | No | Positive if Greater Than or Equal To* | Sensitivity | 1 - Specificity | Specificity |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -1.00 | 1.000 | 1.000 | 0.000 | 15 | 6.25 | 0.400 | 0.167 | 0.833 |
| 2 | 0.25 | 0.971 | 0.742 | 0.258 | 16 | 6.75 | 0.371 | 0.152 | 0.848 |
| 3 | 0.58 | 0.914 | 0.682 | 0.318 | 17 | 7.25 | 0.329 | 0.152 | 0.848 |
| 4 | 0.83 | 0.914 | 0.667 | 0.333 | 18 | 7.75 | 0.314 | 0.121 | 0.879 |
| 5 | 1.25 | 0.857 | 0.621 | 0.379 | 19 | 8.50 | 0.229 | 0.106 | 0.894 |
| 6 | 1.75 | 0.800 | 0.576 | 0.424 | 20 | 9.50 | 0.157 | 0.076 | 0.924 |
| 7 | 2.50 | 0.729 | 0.515 | 0.485 | 21 | 10.25 | 0.143 | 0.061 | 0.939 |
| 8 | 3.25 | 0.700 | 0.424 | 0.576 | 22 | 10.75 | 0.129 | 0.045 | 0.955 |
| 9 | 3.58 | 0.686 | 0.424 | 0.576 | 23 | 11.25 | 0.086 | 0.030 | 0.970 |
| 10 | 3.83 | 0.671 | 0.424 | 0.576 | 24 | 12.00 | 0.043 | 0.030 | 0.970 |

| No | Positive if Greater Than or Equal To* | Sensitivity | 1 - Specificity | Specificity | No | Positive if Greater Than or Equal To* | Sensitivity | 1 - Specificity | Specificity |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 4.25 | 0.629 | 0.364 | 0.636 | 25 | 13.00 | 0.029 | 0.015 | 0.985 |
| 12 | 4.58 | 0.543 | 0.303 | 0.697 | 26 | 14.00 | 0.014 | 0.015 | 0.985 |
| 13 | 4.83 | 0.543 | 0.288 | 0.712 | 27 | 15.50 | 0.000 | 0.000 | 1.000 |
| 14 | 5.50 | 0.500 | 0.258 | 0.742 | | | | | |

*ROC Curve test of Physical activity on CKD

**Sensitivity, Specificity, and Cut-off of Psychological Stress Effect on CKD**

The Roc curve analysis below shows that Psychological Stress in the good category predicts chronic kidney disease in Kendari City. The ROC Curve shows an AUC of Psychological Stress to predict people with chronic kidney diseases is 76.1% with a 95% confidence interval of 64.6% and 87.7% (Table 5). This means that there are around 23.9% of other factors besides Psychological Stress factor which influence CKD.

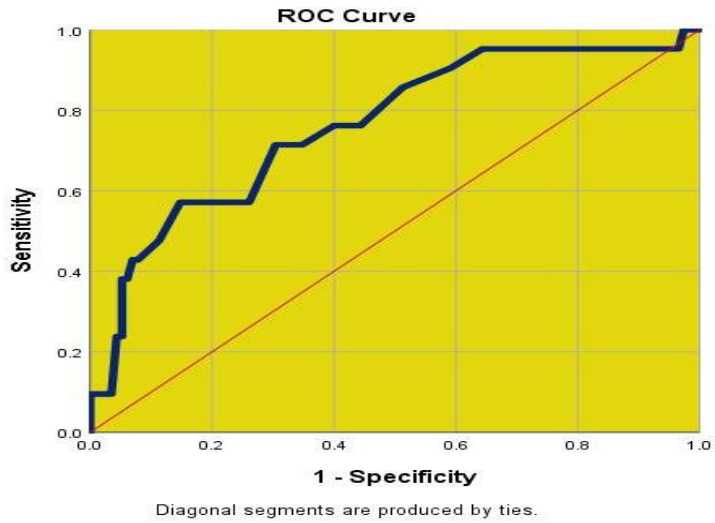


**Figure 3.** Sensitivity and Specificity of Psychological Stress Effect on Chronic Kidney Disease in Kendari City

The number of individuals who were not stressed and did not suffer from chronic kidney disease is 21 people (Table 5). Meanwhile, the number of individuals who were stressed and suffering from chronic kidney disease is 115 people. This means that individuals who were not stressed have a high chance of not suffering from chronic kidney disease. On the other hand, individuals who were stressed are more likely to suffer from chronic kidney disease.

**Table 5.** Area Under the Curve of Psychological Stress

| Area (AUC) | Std. Error[a] | Asymptotic Sig.[b] | Asymptotic 95% Confidence Interval | | Positive[C] | Negative |
|---|---|---|---|---|---|---|
| | | | Lower Bound | Upper Bound | | |
| 0.761 | 0.059 | 0.000 | 0.646 | 0.877 | 21 | 115 |

a. Under the nonparametric assumption
c. The positive actual state is 0
b. Null hypothesis: true area = 0.5

The cut-off point for Psychological Stress as a warning limit for chronic kidney disease is shown in the cross-sectional graph below, which is generated from the sensitivity and specificity values for Psychological Stress in chronic kidney disease in Kendari City (Figure 4).

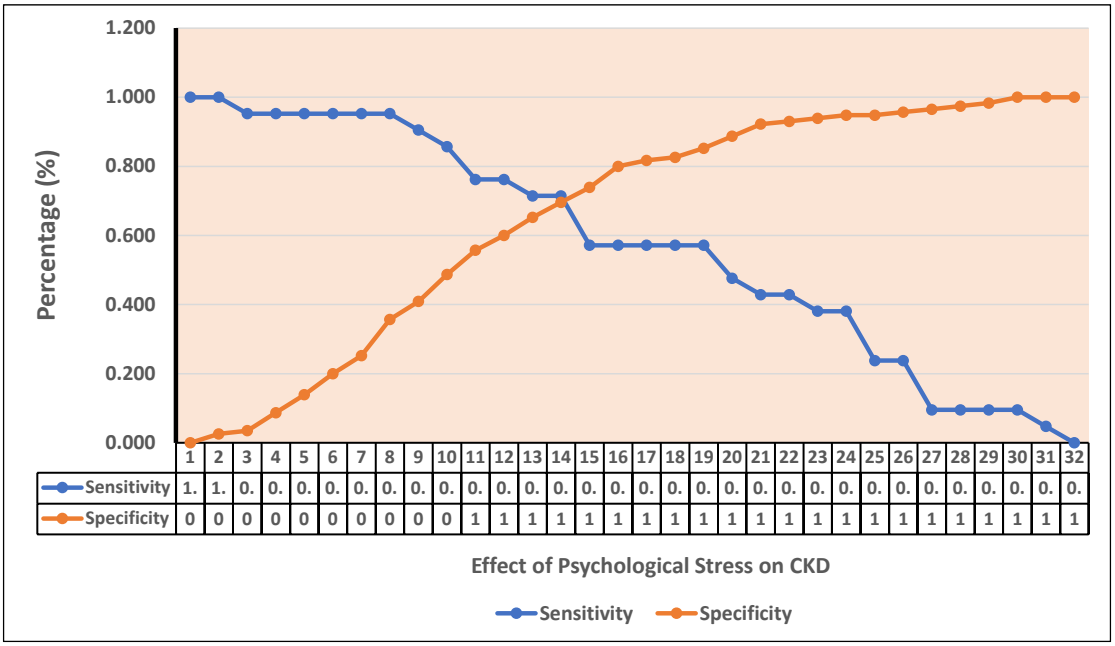


**Figure 4.** The Cut-off of Psychological Stress on CKD in Kendari City

The graph above shows the intersection point between the sensitivity and specificity values at number 14th with a sensitivity value of 0.714 (71.4%) and a specificity of 0.696 (69.6%) (table-6). Based on the test result variable: positive if greater than or equal to the smallest cutoff value is 12.50. This value means that the cutoff value for psychological stress in CKD is 12.50 or in the mild stress category. This cut-off point means that if an individual's psychological stress condition is below 12.50 or mild stress, there is a 71.4% chance that they will not suffer from chronic kidney disease. However, if an individual's psychological stress condition is above than 12.50 or mild stress, there is a 69.6% chance of suffering from chronic kidney disease.

**Table 6.** Coordinates of the Curve of Psychological Stress

| No | Positive if Greater Than or Equal Toa | Sensitivity | 1 - Specificity | Specificity | No | Positive if Greater Than or Equal Toa | Sensitivity | 1 - Specificity | Specificity |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -1.00 | 1.000 | 1.000 | 0.000 | 17 | 15.50 | 0.571 | 0.183 | 0.817 |
| 2 | 0.50 | 1.000 | 0.974 | 0.026 | 18 | 16.50 | 0.571 | 0.174 | 0.826 |
| 3 | 1.50 | 0.952 | 0.965 | 0.035 | 19 | 17.50 | 0.571 | 0.148 | 0.852 |
| 4 | 2.50 | 0.952 | 0.913 | 0.087 | 20 | 18.50 | 0.476 | 0.113 | 0.887 |
| 5 | 3.50 | 0.952 | 0.861 | 0.139 | 21 | 19.50 | 0.429 | 0.078 | 0.922 |
| 6 | 4.50 | 0.952 | 0.800 | 0.200 | 22 | 20.50 | 0.429 | 0.070 | 0.930 |
| 7 | 5.50 | 0.952 | 0.748 | 0.252 | 23 | 21.50 | 0.381 | 0.061 | 0.939 |
| 8 | 6.50 | 0.952 | 0.643 | 0.357 | 24 | 22.50 | 0.381 | 0.052 | 0.948 |
| 9 | 7.50 | 0.905 | 0.591 | 0.409 | 25 | 23.50 | 0.238 | 0.052 | 0.948 |
| 10 | 8.50 | 0.857 | 0.513 | 0.487 | 26 | 24.50 | 0.238 | 0.043 | 0.957 |
| 11 | 9.50 | 0.762 | 0.443 | 0.557 | 27 | 25.50 | 0.095 | 0.035 | 0.965 |

| No | Positive if Greater Than or Equal Toa | Sensitivity | 1 - Specificity | Specificity | No | Positive if Greater Than or Equal Toa | Sensitivity | 1 - Specificity | Specificity |
|---|---|---|---|---|---|---|---|---|---|
| 12 | 10.50 | 0.762 | 0.400 | 0.600 | 28 | 27.00 | 0.095 | 0.026 | 0.974 |
| 13 | 11.50 | 0.714 | 0.348 | 0.652 | 29 | 29.00 | 0.095 | 0.017 | 0.983 |
| 14 | 12.50 | 0.714 | 0.304 | 0.696 | 30 | 30.50 | 0.095 | 0.000 | 1.000 |
| 15 | 13.50 | 0.571 | 0.261 | 0.739 | 31 | 31.50 | 0.048 | 0.000 | 1.000 |
| 16 | 14.50 | 0.571 | 0.200 | 0.800 | 32 | 33.00 | 0.000 | 0.000 | 1.000 |

*ROC Curve test of Psychological Stress

## DISCUSSION

### Physical activity and chronic kidney disease

This research shows that physical activity and psychological stress have a significant effect on the occurrence of chronic kidney disease for individuals in Kendari City. The physical activity variable has an ability of 68.6% in predicting chronic kidney disease, with an interquartile range from 59.7% to 77.5%. The level of ability of physical activity variables to influence chronic kidney disease is classified as moderate. It is said that the health benefits of regular physical activity are indisputable. The fact is that everyone can benefit from regular physical activity both at home and at work (33). This research means that physical activity can prevent someone from developing chronic kidney disease. Previous research also supports that physical activity in various forms can have a good influence on kidney health, both in people who are still healthy and in people who already have chronic kidney problems (14). The higher the physical activity, the more protective factor it is in chronic kidney disease (34).

This study suggests that the cut-off point for physical activity as a limit for preventing chronic kidney disease is 4.25 hours per day. The cutoff point value for physical activity shows 4.25 hours per day, meaning that if an individual's physical activity is equal to or above 4.25 hours per day, then they are likely to avoid CKD. If physical activity is less than 4.25 hours per day, it is possible that they will develop chronic kidney disease. This is supported by other studies that the more movement, the more a person will avoid the risk of chronic kidney disease, including physical activity in their work environment (35). Other study states Individuals are also expected to move around 4000 steps per day to avoid CKD (36). The results of this study also strengthen the WHO recommendation that adults should do moderate intensity aerobic physical activity for at least 150-300 minutes or the equivalent of 2.5-5 hours (37). Furthermore, adults should at least do high intensity aerobic physical activity for around 75-150 minutes or 1.25-2.5 hours. Doing a combination of moderate and vigorous physical activity throughout the week and the results have been shown to provide great benefits for adults.

Moreover, this study also shows the sensitivity level the sensitivity level of physical activity with a cut-off point of 4.25 hours per day shows 62.9%, which means that out of 100 people whose physical activity is 4.25 hours per day, there are around 63 people who are not affected by CKD. This means that there are 37 people who suffer from CKD even though they have physical activity of around 4.25 hours per day. The results of this study also mean that the causes of them suffering from CKD are other factors, such as gender, socio-economic status, ethnicity, health services, smoking, diet, rest, and environmental sanitation factors (38–41). Meanwhile, the specificity value of physical activity with a cut-off point of 4.25 hours per day is 63.6%, which means that out of 100 people who do less than 4.25 hours per day of physical activity, there are around 64 people who suffer from CKD. This evidence also means that the risk factor for chronic kidney disease is not only high levels of physical activity.

The influence of physical activity on disruption of kidney function and structure can occur in various ways. One influence is through the cardiorespiratory system and cardiovascular system (34,42). People do good physical activity can provide protection for cardiorespiratory fitness which allows the heart to beat and the body's cells to work. This condition allows maximum fat and calorie burning (43). In this way excess fat and calories can be avoided. Furthermore, the influence of sufficient physical activity on the cardiovascular system makes it possible to transport oxygen and nutrients to muscle tissue, in addition to transporting the waste products of the body's metabolism. Therefore, there is sufficient nutrition and oxygen for the muscles or organs in the body, which allows all organs to be healthy and function normally, including the kidneys.

There are many ways a person can do physical activity, apart from strenuous exercise such as running, gymnastics or fitness. Household activities are also physical activities that require energy, such as cleaning the house, cooking, washing clothes and dishes without a machine, taking care of children, and so on. Besides that, activities at work range from light to heavy physical activity. Forms of physical activity in the form of sports are from the light sports category such as walking, to the heavy sports category. Furthermore, WHO states that physical activity for adults can be done as part of their free time or part of their recreation, for example playing, sports, cycling, walking, daily household work, education, or social interactions in their social environment (37).

**Psychological Stress and Chronic Kidney Disease**

Compared to the strength of the influence of physical activity, the influence of the psychological stress variable is stronger as a marker of the possibility of chronic kidney disease. As explained in the results above, the AUC value of the psychological stress variable in CKD is 76.1%, with an interquartile range between 64.6% and 87.7%. This value shows that the ability of psychological stress to influence CKD is classified as strong. This means that the psychological stress has a greater ability to predict the possibility of chronic kidney disease in individuals compared to physical activity. Meanwhile, the cut-off points for the psychological stress at CKD, namely at level 12.50 or in the category mild stress. This shows that if someone experiences the same as or above mild stress psychological disorders, they will have the possibility to suffer from chronic kidney disease. Previous studies also stated that someone who started with a mild level of psychological stress disorder tended to be 4.72 (95% CI=2.97–7.48) times more likely to develop chronic kidney disease (44).

Furthermore, as explained above, the sensitivity level of the psychological stress with a cutoff point of 12.50 is 71.4%. This means that out of 100 people who are not stressed, there are around 72 people who do not suffer from CKD. Therefore, there are around 28 people who are not stressed, but they are likely to experience CKD. This evidence shows that there are other factors that cause a person to develop CKD in Kendari besides psychological stress. Previous studies explained that other risk factors for CKD are unhealthy behaviours, such as unbalanced diet, lack of water consumption, bad environmental sanitation, smoking, socio-economics, gender and ethnicity (38,40,41,44,45).

As explained above, this study also shows that the specificity value of the psychological stress variable with a cutoff point of 12.50 is 69.6%. This value means that out of 100 people who experience mild stress, there are around 70 people who suffer from CKD. This means that there are around 30 people who are mildly stressed, but they do not experience CKD. This data also shows that the cause of CKD is not only psychological stress, but there are many other risk factors, as explained above.

There are many factors that can be explained why psychological stress can influence to CKD. Firstly, psychological stress can cause changes or disturbances in the function of organs in the human body, namely disturbances in brain function, the immune system, the cardiovascular system, and the gastrointestinal system. and endocrine system disorders (21). Disorders of brain function result in disturbances in the central nervous system, causing structural changes in parts of the brain (46). In this condition, stress causes brain mass atrophy, weight loss, memory, cognitive and learning disorders (47).

Furthermore, if the function of the immune system is disturbed, individuals become susceptible to disease, especially infectious diseases (48). In this case, stress acts as a mediator by passing through the blood-brain barrier and having an effect on the immune system. Meanwhile, if the function of the immune system is disturbed, it will modulate processes in the body through the central nervous system and neuroendocrine system (21). At this stage, the neuroendocrine system and nervous responses will result in the release of corticotrophin-releasing hormone, adrenocorticotropic hormone, and other hormones (49).

Moreover, if the function of the cardiovascular system is disrupted through activation of the autonomic system, it will cause interference with the activation of the sympathetic nervous system (50). This condition will have an impact on increasing heart rate, contraction, vasodilation in skeletal muscle arteries, narrowing of veins, contraction of arteries in the spleen and kidneys, and decreased sodium excretion by the kidneys (21). This is what links stress to chronic kidney disease. It is clearer that even in mild stressful conditions, stress can cause disturbances in the body, ranging from changes in homeostasis to threats to human life.

**Implications for Public Health Policy and programs**

From the explanation above, it is clear that physical activity and psychological stress can affect kidney function, leading to chronic kidney disease. The results of this study have implications for the need to develop public health policies and programs towards controlling CKD in Kendari City. Policy development that leads to CKD control is the existence of regulations that contain the following aspects:

Development and implementation of infrastructures towards a healthy and conducive city which allows people in Kendari City to be able to carry out light to heavy physical activities, such as walking and running. Besides that, the development and implementation of infrastructure which allows residents to relax or have recreation after being busy with tiring and boring daily activities.

Creating an atmosphere or program for all agencies and organizations in Kendari City that allows all employees to have the opportunity to carry out physical activity as recommended by this study, namely 4.25 hours per day.

Creation of harmonious social conditions that enable citizens to avoid psychological pressures aimed at the government, private sector and society.

The results of this study also have implications for the development of public health programs to increase physical activity and reduce psychological stress, including: 1) Construction of road infrastructure with sidewalks that allow pedestrians and cycling can occur without disturbing vehicle traffic on the road. 2) Construction of city parks that enable residents to relax or have recreation after being busy with tiring and boring daily activities. 3) Development of a joint exercise program at certain times. 4) Implementation of a 15–30-minute stretching or light exercise program for employees in all agencies, both government and private agencies in the Kendari City area.

**Limitations of this study**

This study used accidental sampling techniques in data collection, and this may affect generalizations for the influence of physical activity and psychological stress on chronic kidney disease. Apart from that, reporting on time for physical activity is also based on participants' estimates, so there may be potential bias in the calculation of reported physical activity time. Likewise, data on psychological stress conditions were also based on the participants' perceptions about their psychological condition when they were interviewed. However, the psychological stress condition which occurred previously is not identified, so the cut-off points, the level of sensitivity and specificity of psychological stress on CKD may be different when carried out with different methods.

**Recommendations for Future Research**

Based on the limitations of this research, future researchers can improve the methods of this research. For example, the selection and use of a more random sampling technique will better generalize the influence of physical activity and psychological stress on CKD. Accurate calculation of time for carrying out physical activity such as with a stop watch also needs to be done in future studies. This may result in differences in cut-off points, sensitivity and specificity of physical activity for CKD. Likewise, collecting data about psychological conditions can be collected consecutively, for more than 24 hours, which allows generalizations to be represented.

## CONCLUSION

This study has shown how physical activity and psychological stress can predict the occurrence of chronic kidney disease for individuals in the Kendari City area. The cut-off points of physical activity are 4.25 hours per day with 62.9 % of the level of sensitivity and 63.6% of the specificity level. People with physical activity equal to or higher than 4.25 hours per day, then 62.9% of them do not suffer from chronic kidney disease. Meanwhile, someone with a mild level of psychological stress (score $\geq$ 12.5) has a 71.4% chance of experiencing chronic kidney disease. The cut-off points for psychological stress are 12.5 or classified as mild stress, with a sensitivity level of 71.4% and 69.6% for the specificity level.

The results of this study have implications for the need to develop policies and programs that aim at controlling or preventing chronic kidney disease which is associated with physical activity and psychological stress. Program policy development needs to include elements of infrastructure development that enable residents in the city of Kendari to carry out physical activities such as walking or sports, as well as recreation. Harmonious social conditions that enable people to live safely and comfortably also need to be regulated in the policy and programs.

This research contributes to the basic development of health promotion and prevention towards controlling chronic kidney disease which is associated with encouraging physical activity and improving the psychological condition of society, especially in Kendari City.

Due to the limitations of this research, future research needs to use a sampling method where each population has the same opportunity. Thus, the generalization of study results regarding the cut-off point, sensitivity and specificity of physical activity and psychological stress on chronic kidney disease can be applied to different conditions.

## AUTHOR'S CONTRIBUTION STATEMENT

The authors confirm contribution to the paper as follows: study conception and design: Tasnim Tasnim (TT). Data collection: TT, Imran (IM), Sugireng (SG), Nur Illiyin Akib (NIA). Analysis and interpretation of results: TT, SG. Draft manuscript: TT. Preparation: TT. All authors reviewed the results and approved the final version of the manuscript.

## CONFLICTS OF INTEREST

The authors declared that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

## SOURCE OF FUNDING STATEMENTS

The authors received financial support from Ministry of Education, Culture, Research and Technology of the Republic of Indonesia for the research, authorship, and/or publication of this article.

## ACKNOWLEDGMENTS

The authors appreciate the Ministry of Education and Culture, Research and Technology of the Republic of Indonesia for funding support for this research. Thus, the author would like to thank to Abeli, Mata, Kandai, and Lepo-Lepo Health Centres, and Bahteramas, Santa Anna and Kendari City Hospitals for their facilities and information support.

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