Int.J.Curr.Res.Aca.Rev.2025; 13(8): 22-28

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 13 Number 8 (August-2025)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2025.1308.003

Evaluation of Cardiac Recovery in Teenager Girls with Anaemia after the Ruffier-Dickson Test

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Abstract

The impact of physical activity and sport on people with anaemia is an important subject for study. The aim of our research is to compare the cardiac recovery of anaemic girls with that of healthy girls after the Ruffier-Dickson test. This study was carried out on 26 female students from one Senegalese high school, aged between 17 and 20, who regularly took part in Physical Education and Sport (PE) classes. The sample was divided into two groups: an experimental group of 13 anaemic girls and a control group of 13 healthy girls. The protocol consisted of measuring their heart rate at rest, administering the Ruffier-Dickson test, then recording their heart rate immediately after exercise, as well as every minute of recovery up to the fifth minute. The mean values of the variables measured during the three phases of the protocol were compared. There was a statistically significant difference between the mean values of heart rate measured at rest, immediately after the Ruffier-Dickson test, and after each minute of recovery. Percentage changes in the rate of change of average heart rates show that anaemic girls show a -57% decrease at the fifth minute of recovery, while healthy girls show a -77% decrease at the same time. Our study shows that anaemic secondary school girls recover less quickly than their healthy counterparts after the Ruffier-Dickson test.

Article Info

Received: 05 June 2025
Accepted: 26 July 2025
Available Online: 20 August 2025

Keywords

Anemia, teenager girls, cardiac recovery, heart rate, Ruffier-Dickson test

Introduction

Anemia is defined as a decrease in the concentration of haemoglobin in the blood, often accompanied by a reduction in the number of red blood cells. This can lead to a reduction in the blood's ability to carry oxygen, causing symptoms such as fatigue, weakness, dizziness and palpitations (Guyatt and Oxman, 1992).

It wasn't until the XIXth century, with advances in medicine and understanding of blood physiology, that anaemia began to be studied more scientifically. In the mid XIXth century, Thomas Addison described a specific form of anaemia now known as Addison-Biermer disease or pernicious anaemia. Subsequent research has uncovered a variety of causes of anaemia, including nutritional deficiencies, chronic diseases, and genetic disorders (Greer *et al.,* 2009). Despite the remarkable improvement in living conditions over the last few decades, anaemia remains a major public health problem, affecting physical growth, cognitive development, reproduction and physical work capacity, resulting in reduced human performance. It has been classified by the World Health Organisation as one of the ten most serious problems in the modern world and is the most common form of micronutrient deficiency in the world (Agarwal *et al.,* 1991). Anaemia is a major public health problem, mainly affecting young children, pregnant women, adolescents and menstruating women (WHO, 2023).

One milliliter of blood contains 0.5 mg of iron. Acute haemorrhage alone, if not corrected by blood transfusions, can lead to iron deficiency anaemia. As a rule, however, the aetiology is not a problem. On the other hand, chronic occult bleeding that is detected late can lead to severe iron-deficiency anaemia. It is important to know that bleeding is most often genital in origin. Blood loss due to menstrual bleeding is around 30 to 40 ml in a normally regulated woman. However, the amount of menstrual flow is difficult to determine for most women.

Moreover, women are not always aware of the increase in blood loss, in the form of clots, when their periods are longer and heavier than usual. Anemia is all the more marked when abnormal bleeding occurs over a long period of time (LONGPRÉ, 1994). Anaemia in adolescents is mainly caused by iron deficiency, often due to insufficient consumption of iron-rich foods or poor absorption of this mineral. Iron requirements increase significantly during adolescence due to rapid growth and body changes, particularly in girls as a result of menstrual blood loss (Brabin *et al.,* 2001). These studies have shown that iron deficiency, with or without anaemia, leads to reduced physical activity, increased vulnerability to infection, impaired physical development and may also lead to permanent psychomotor disorders in this age group (Badham *et al.,* 2007).

Assessment of physical performance during exercise in groups of subjects with the same haemoglobin level but high or low serum iron levels revealed differences in their ability to cope with a series of exercises. This work suggests that tissue iron deficiency may be associated with physical performance, independently of oxygen transport to the tissues. Ultimately, iron deficiency in athletes reduces aerobic capacity, increases heart rate and lengthens recovery time after exercise (Schumacher *et al.,* 2002.).

As a teacher of physical education and sport, I've noticed that in some of my third and second year classes, some girls ask me to give them extra minutes to recover doing the next rehearsal or starting the second series of rehearsals, while others carry on without complaining. Having noted a few first names and surnames and submitted them to the school's medical service nurse, her response, after consulting the school's medical records, revealed that they were all anaemic. In addition, to my knowledge, the literature has not reported any study carried out in Senegal on the recovery of anaemic teenage girls after physical effort.

With this in mind, we propose to study the cardiac recovery of anaemic secondary school girls after a Ruffier-Dickson test. To this end, we formulated the following hypothesis:

H0: High school girls with anaemia recover less quickly than their healthy counterparts after the Ruffier-Dickson test.

To confirm or refute our hypothesis, we compared the recovery of anaemic girls after the Ruffier-Dickson test with that of healthy girls.

Materials and Methods

Study sample

A sample of 26 girls was chosen from the pupils of Blaise Diagne high school in Dakar. This sample is made up of two groups: a group of 13 anaemic girls, constituting the experimental group, and a group of 13 healthy girls, constituting the control group. The girls were black Senegalese.

They take part in the Physical Education and Sports (PES) course.

Anemia girls (experimental group)

Each girl was selected on the basis of her medical file, which clearly stated "mild anaemia, haemoglobin concentration below 120g/l, but no other illness".

Healthy girls (control group)

They were chosen after consultation of their medical records. They all have a haemoglobin concentration of over 120g/l and do not suffer from any pathology.

Evaluation of variables

Weight measurement

Weight was measured using a Seca 762 mechanical scale.

It features a large, easy-to-read round dial with a 1kg scale. This scale uses a lever system to accurately measure the user's weight. The user stands on the scale with bare feet and a straight torso. Using a pointer, the weight value is indicated on the dial in kilograms (kg) with a capacity of 150 kg.

Size measurement

The size was measured in cm using a micro wall bracket. This is easy to fit thanks to three fixing screws. The height rod was fixed 220 cm above the ground to give a correct measurement. The subject stands, barefoot, with his or her back against the wall, perpendicular to the fixed height rod, with a straight chest and horizontal gaze. The measurement is easily taken by pulling out the graduated meter. Readings are quick and accurate thanks to the window that conceals unnecessary measurements.

Heart rate measurement

The heart rate was measured in beats per minute using a Bluetooth heart rate sensor, which measures a person's heart rate in real time and then transmits the data to the connected phone.

To use the Bluetooth heart rate sensor, you first need to wear it correctly. It is worn as a belt around the chest. Then connect the device via Bluetooth by activating Bluetooth on the smartphone to open the dedicated Decathlon application. Finally, you launch the measurement in the application by selecting the option to start a session and monitor your heart rate. The sensor sends live data to your smartphone (time, heart rate, etc.).

Description of the Ruffier-Dickson test (38)

The Ruffier or Ruffier-Dickson test is a cardiac recovery test used to assess fitness for sport. The Ruffier test should be performed under the supervision of a health or fitness professional.

The Ruffier-Dickson test gives a better idea of a person's state of fitness based on their heart rate following a well-known bodybuilding exercise, the free squat.

Ruffier-Dickson test procedure

Recording of resting heart rate before the Ruffier test (FCR)

The girls go to high school infirmary. Once there, they wear the heart rate sensor connected to their phone via Bluetooth and lay down for 5 minutes before having their resting heart rate measured.

The heart rates are collected by INSEPS head nurse Samba Gueye and the nurse on duty in the school's medical department.

Recording of heart rate after the Ruffier test (FCA)

The girl stands with her legs about shoulder-width apart, back straight and arms outstretched in front. The time is triggered on the application on the phone connected to the sensor via Bluetooth and she completes 30 full squats in 45 seconds, then her heart rate is immediately taken and displayed on the phone.

Record your heart rate from the first to the fifth minute of recovery (HR1, HR2, HR3, HR4, HR5)

After these 30 flexions, the subject lies down again, and his or her heart rate is recorded every minute of recovery after the effort has stopped, up to the fifth minute.

Statistical processing

We first compared the mean values of age, weight, height and heart rate of the experimental group with those of the control group using the T-STUDENT test, a parametric test applied if and only if normality (Gaussian distribution) and equality of variances (homoscedasticity) were established.

Once the normality of the data had been verified and the equality of the variances established, we performed the Student's t test to confirm or refute our hypothesis below:

H: there was a significant difference in mean age, weight, height and heart rate between the group of anaemic girls (experimental group) and the group of healthy girls (control group).

Our probability of error α is set at 5% (0.05). This is the margin of error we accept in deciding on the difference between the means.

If the probability of error P found in the Student test is less than or equal to α ($P \leq \alpha$), we say that there is a significant difference between the two groups.

If the probability of error found in the test is greater than α ($P > \alpha$), we will say that there is no significant difference between the means of the two groups.

Calculating the rate of change of heart rate each minute after the Ruffier-Dickson test enabled us to obtain the rate cardiac recovery for each girl up to the fifth minute.

To calculate the rate of change, you need an initial value (the heart rate reached at the end of the Ruffier-Dickson test) and a final value (the heart rate at each minute of recovery up to the fifth: HR1, HR2, HR3, HR4, HR5).

Rate of change = [(Arrival value - Departure value) / Departure value] x 100

If the rate is > 0%, or positive, the variable or phenomenon increases.

If the rate is < 0%, or negative, the phenomenon or variable decreases.

If the rate is = 0, or zero, the phenomenon or variable is stable

We then plotted the variation in average heart rate for each group after the test.

We have also presented in the same figure the curves for the average rates of change in heart rate for the two groups during recovery from the Ruffier-Dickson test.

Results and Discussion

The results of the Student's t test show that there were no significant differences in age (table 1), weight (table 2) or height (table 3) between the experimental group and the control group. These variables cannot therefore bias the comparison of the other variables in the two groups. However, the mean resting heart rate of the experimental group (71 bpm) was significantly ($p = 0.02$) higher than that (68 bpm) of the control group. This result suggests that anaemia is associated with an increase in resting heart rate in girls. This increase in resting heart rate in anaemic girls could be explained by an oxygen deficit due to a lack of iron, the iron atom contained in red blood cells that binds to oxygen molecules to transport them. It should be remembered that oxygen is transported in the blood in two forms (Larry *et al.,* 2021): either in bound form, i.e. combined with the haemoglobin (Hb) of the red blood cells (> 98%), or in a form dissolved in the plasma (< 2%). This deficiency of iron in red blood cells, particularly in adolescent girls as a result of menstrual blood loss (Brabin, 2001), leads to an increase in the rate of contraction of the heart to supply much more blood and thus meet the body's oxygen requirements. This higher resting heart rate in anaemic girls than in healthy girls suggests that particular attention should be paid to anaemic girls, as their heart rate will reach high values much more quickly, limiting their physical engagement (Badham, 2007). Girls with anaemia have also been reported to suffer from constant fatigue and general weakness, palpitations, cardiac hypertrophy, heart failure and angina attacks in predisposed individuals. These anaemic girls may have difficulty breathing, especially during physical effort, due to the reduced oxygenation capacity of the blood (Cappellini and Motta, 2015).

As the resting heart rates of the anaemic girls were significantly higher than those of the non- anaemic girls (Table 4), it would be an aberration to compare their mean heart rates at the end of the Ruffier-Dickson test and during recovery. For this reason, we compared the rates of change in heart rate of the two groups during each minute of recovery after the test up to the fifth minute, which is more relevant

The rates of change obtained from the first to the fifth after the Ruffier-Dickson test show that the heart rate of both groups decreases progressively. However, a comparison of the rates of change in the heart rates of the two groups reveals that the heart rates of the non-anaemic girls fall much faster than those of the anaemic girls. In other words, the heart rate of the non-anaemic girls returned much more quickly to its resting value than that of the anaemic girls after a moderate effort such as the Ruffier-Dickson test. The rate of change was -25% in the non- anaemic girls and -13% in the anaemic girls at the end of the first minute of recovery. It was -43% for non-anaemic girls and -25% for anaemic girls at the end of the second minute of recovery. It was -53% in non-anaemic patients and -36% in anaemic patients at the end of the third minute. It was -65% for non-anaemics and -49% for anaemics at the end of the fourth minute, and -77% for non-anaemics and -59% for anaemics at the end of the fifth minute.

This suggests that normal girls recover much more quickly than anaemic girls after moderate exercise.

These results show that girls with anaemia have difficulty recovering cardiac function after physical effort, justifying a negative impact of anaemia on their cardiovascular capacity. The inferior performance of anaemic girls could reflect an adapted cardiac response to physical stress, given that they suffer from reduced oxygen transport.

Table.1 *Comparison of the average age of the group of anaemic girls (experimental group) with that of normal girls (control group).*

Variables	Ages	
Topics	AN	NO
Average	18,62	17,92
Type gap	1,12	1,04
α	0,05	
P(found)	0,11	
Decision	NS	

AN: anaemic girls, **NO:** normal girls, **α:** probability of error set as the significance threshold, **P (found):** the probability of error found in the Student test, **NS:** not significant

Table.2 *Comparison of the average weight of the group of anaemic girls (experimental group) with that of normal girls (control group).*

Variables	Weight	
Topics	AN	NO
Average	54,46	55,92
Type gap	9,13	9,69
α	0,05	
P(found)	0,69	
Conclusion	NS	

Table.3 *Comparison of the average height of the group of anaemic girls (experimental group) with that of normal girls (control group).*

Variables	Sizes	
Topics	AN	NO
Average	163,23	163,46
Type gap	5,04	3,26
α	0,05	
P(found)	0,89	
Conclusion	NS	

Table.4 *Comparison of the average resting heart rate of the group of anaemic girls (experimental group) with that of normal girls (control group).*

Variables	FCR	
Topics	AN	NO
Average	71,77	68,15
Type gap	3,004	2,34
α	0,05	
P(found)	0,002	
Conclusion	S	

S: significant

Fig.1 *Changes in the average heart rate of the group of anaemic girls (experimental group) and non-anaemic girls (control group) during the Ruffier-Dickson test up to the fifth minute of recovery after the test.*

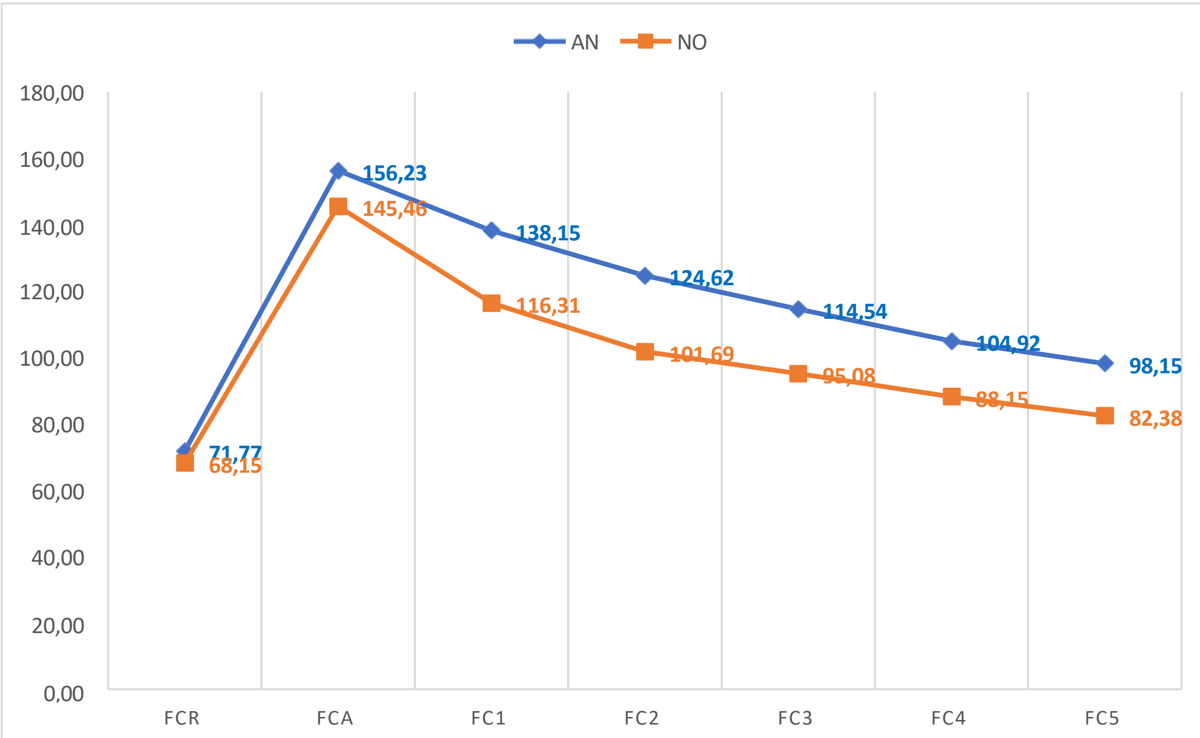
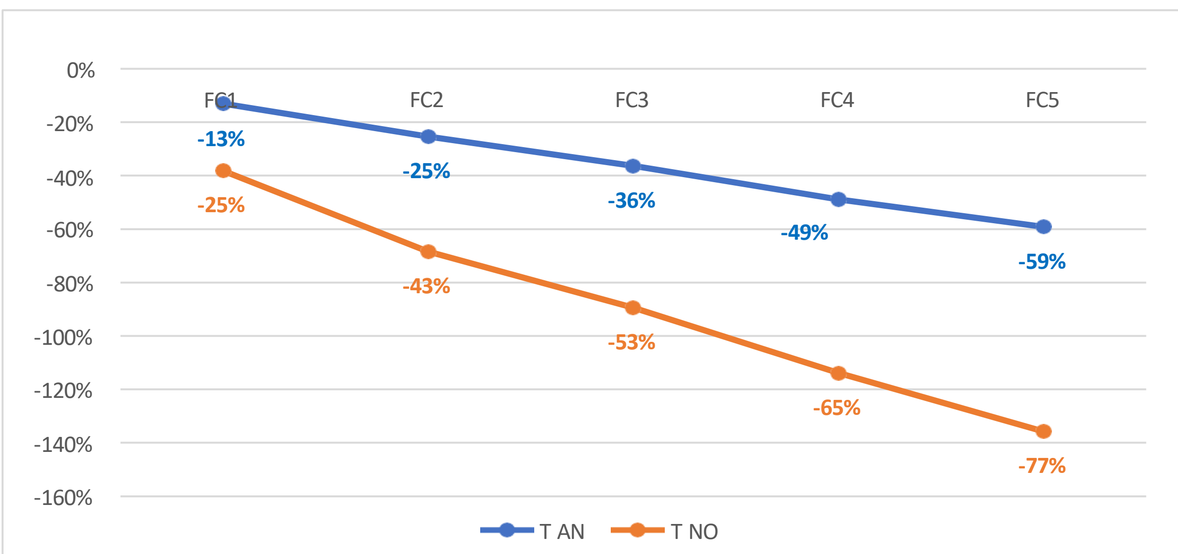


Fig.2 *Percentage change in the average heart rate of anaemic girls (experimental group) and normal girls (control group) after each minute of recovery up to the fifth minute.*



The tendency for anaemic girls to have a higher heart rate throughout the recovery period can be interpreted as an adaptive response of the heart to the reduced oxygen availability due to weak red blood cells and reduced haemoglobin. This may indicate an inability to recover effectively after exercise, which may have implications for their physical performance and ability to participate in physical activities.

Cardiac recovery offers valuable insights into understanding the pathophysiological effects of anaemia, particularly in active adolescent girls. The impaired ability to recover after physical activity highlights the importance of addressing and treating anaemia to improve performance and general health in this population.

In conclusion, 26 female students from one high school, aged 17 to 20, who were regular attenders of Physical Education and Sport classes, took part in our study. These girls were divided into two groups: anaemic girls and non-anaemic girls. The results revealed that anaemic girls have a higher resting heart rate and a more pronounced initial cardiac response after exercise, which can be described as a compensatory mechanism in the face of reduced oxygen transport capacity. In addition, the rates of change in heart rate showed that anaemic girls took longer to recover, which could have a negative impact on their physical performance and well-being.

This confirms our hypothesis that anaemic secondary school girls recover less quickly than their healthy counterparts after the Ruffier-Dickson test.

The present study recommend, Cardiology care for anaemic teenage girls, authorised to take part in physical and sporting activities. Essential iron supplements to improve their physical condition and quality of life, the Physical Education and Sport (PE) teacher to be attentive, while giving priority to progressive exercises adapted to the physical condition of anaemic teenage girls and allowing them longer recovery times.

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How to cite this article:

Mountaga Diop, Ndarao Mbengue, Ndiack Thiaw and Papa Serigne Diène. 2025. Evaluation of Cardiac Recovery in Teenager Girls with Anaemia after the Ruffier-Dickson Test. *Int.J.Curr.Res.Aca.Rev.* 13(08), 22-28.
doi: https://doi.org/10.20546/ijcrar.2025.1308.003