

Unveiling the Mental State: Validating the uBioMacpa Pro Stress Measurement Tool among Chinese College Students (#102317)

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I commend the authors for their extensive data set, compiled over many years of detailed fieldwork. In addition, the manuscript is clearly written in professional, unambiguous language. If there is a weakness, it is in the statistical analysis (as I have noted above) which should be improved upon before Acceptance.

Unveiling the Mental State: Validating the uBioMacpa Pro Stress Measurement Tool among Chinese College Students

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Mental stress is one of the major factors that contribute to a variety of health problems among others like cardiovascular disease, anxiety, and depression. Scholars have developed many tools and methods to evaluate psychological stress states. uBioMacpa Pro is one of the measuring meters that evaluates accumulated stress by measuring heart rate variability (HRV). This study uses reliability and validity tests to validate uBioMacpa Pro among Chinese college students. A total of 60 students (females = 30, males = 30) and 200 (females = 116, males = 84) students with a mean age of 21 years (SD = 1.48, 1.51) were volunteers and recruited in the reliability and validity tests respectively. The reliability test results show that ICC test-retest and inter-rater reliability values are good (ICC > 0.75). Validity assessment was done by exploring concurrent validity that measured the psychological stress of college students by using uBioMacpa Pro and using the validated Chinese versioned Stress Scales for College Students (SSCS) as a reference. The result showed a significant correlation between the uBioMacpa Pro stress index and SSCS questionnaire scores ($r = 0.246$, $p < 0.01$). The overall finding of our study implies that the uBioMacpa Pro has good reliability and validity, and it can be used for monitoring and assessing Chinese college students' mental stress.

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Abstract

Mental stress is one of the major factors that contribute to a variety of health problems among others like cardiovascular disease, anxiety, and depression. Scholars have developed many tools and methods to evaluate psychological stress states. uBioMacpa Pro is one of the measuring meters that evaluates accumulated stress by measuring heart rate variability (HRV). This study uses reliability and validity tests to validate uBioMacpa Pro among Chinese college students. A total of 60 students (females = 30, males = 30) and 200 (females = 116, males = 84) students with a mean age of 21 years (SD = 1.48, 1.51) were volunteers and recruited in the reliability and validity tests respectively. The reliability test results show that ICC test-retest and inter-rater reliability values are good (ICC > 0.75). Validity assessment was done by exploring concurrent validity that measured the psychological stress of college students by using uBioMacpa Pro and using the validated Chinese versioned Stress Scales for College Students (C-SSCS) as a reference. The result showed a significant correlation between the uBioMacpa Pro stress index and C-SSCS questionnaire scores ($r = 0.246$, $p < 0.01$). The overall finding of our study implies that the uBioMacpa Pro has good reliability and validity, and it can be used for monitoring and assessing Chinese college students' mental stress.

Keywords: Mental stress; uBioMacpa Pro; Heart rate variability, Chinese college students.

Introduction

The issue of university students' mental health has always been a concern. In recent years, as social transformation and modernization have accelerated, the numerous issues and contradictions of the new era that accompany them have significantly impacted university students' psychology (Ding

et al., 2021; Yew et al., 2022). A sizeable portion of them suffer from various degrees of psychological disorders and are troubled by anxiety, depression, and other mental problems (Hamaideh et al., 2022; Kovess-Masfety et al., 2016; Liu et al., 2019). Surveys such as that conducted by College Student Mental Health Report Best Colleges showed that many students claimed to experience mental health symptoms most days during the past year, including stress (66%), anxiety (54%), and self-doubt (50%) (Melissa & Megan, 2022). Even as the National Alliance on Mental Illness (NAMI) illustrated, more than 45% of college students dropped out due to mental health-related reasons (Marjorie Baldwin, 2018). Survey participants were asked whether they had gone through a mental health crisis while on campus, and unexpectedly, 73% of respondents experienced it. In this survey, students expressed feeling stressed or overwhelmed about the course load, anxiety, panic, and depression about school and life, as they felt difficulty adjusting to a new routine and environment, all triggering their mental health crisis. The number of undergraduate students in China also reported to suffer from various mental health issues has been increasing, including depression, obsessive-compulsive disorder, anxiety, and interpersonal sensitivity (Huang et al., 2021; Shan et al., 2022). Thus, college students' mental health problems are becoming more and more common.

Presently, there is mounting research that has focused on the mental stress of college students. Therefore, some researchers have developed various techniques to evaluate mental stress states. The most popular method for assessing psychological stress levels is to adopt subjective methods. Most researchers employ self-assessment questionnaires such as the Depression Anxiety Stress Scales (DASS), the perceived stress scale to achieve the respondents' mental states (Andrews & Wilding, 2004; Monroe, 2008). Many studies have used questionnaire scores or self-assessment reports to determine psychological stress status (Gao et al., 2020; Salleh et al., 2021). However, questionnaires are highly subjective. Self-administered questionnaires inevitably suffer from biases, such as respondent bias, acquiescence bias, social desirability bias, etc, which might lead the participants to answer these scales dishonestly (Leeuw, 2012; Rada & Domínguez-Álvarez, 2014). For instance, some respondents may fill in the questionnaire randomly to save time or not read the items carefully, resulting in inaccurate measurement of psychological stress. Consequently, all the self-assessment questionnaires significantly affect the survey results.

Some researchers or healthcare organizations have developed physiological measurement tools to measure psychological stress (Katmah et al., 2021). uBioMacpa Pro was one of such. A Korean medical company developed this device. It evaluates accumulated stress by measuring heart rate variability (HRV) from pulse wave analysis of capillaries. HRV shows the variation in heart rate signal and evaluates the time interval between 2 adjacent R waves (Oh et al., 2021). HRV measurement is a noninvasive quantitative and qualitative tool and a relatively reliable technique for evaluating stress-induced physiological reactions (Rodrigues et al., 2018). The stress index is obtained considering all the data, including pulse variation, heart rate distribution, balance of automatic nerve, and detailed analysis.

Contemporary, there are many stress analysis devices, such as Body Checker and SA-3000P. Compared to these devices, uBioMacpa Pro is lightweight, portable, and easy to measure. Health

issues are becoming a growing concern as individuals are becoming more health conscious. Thus, anybody can quickly test accumulated stress and vascular health status at home using the uBioMacpa Pro device to prevent further disease development.

Currently, some scholars are applying this device for related mental stress studies. Lee et al., (2022) used uBioMacpa Pro to investigate the effect of apartment community garden programs on stress. Choi et al., (2019) also used this device to explore the impact of floral arrangement on the stress index of older people with chronic diseases. Oh et al., (2021) employed uBioMacpa Pro to determine the effect of stress level responses on indoor environmental color properties on heart rate variability. According to available research, Korea is where most current research on the usage of this gadget is concentrated. In China, there needs to be more relevant research on uBioMacpa Pro. Compared to complicated psychiatric examinations and time-consuming psychometric questionnaires, using straightforward electronic devices for stress evaluation is more practical in research practice. Thus, this study addresses this gap by validating the uBioMacpa Pro Stress Measurement Tool, which is essential for accurately assessing stress levels for Chinese college students, as well as providing a trusted measurement tool and reference for stress research in China.

Materials and Methods

Participants

This study involved university students in mainland China. Data were collected from 1st September 2023 to 1st October 2023 at Shangrao Normal University, Shangrao City, China. A total of 260 students volunteered to participate in the study. The study was divided into two parts: -i) A reliability test analysis and ii) A validity test analysis of the uBioMacpa Pro. For the reliability test, 60 university students (30 males and 30 females) from Shangrao Normal University volunteered and participated in this study. For the validity test, the research team assessed the concurrent validity of uBioMacpa Pro. Accordingly, 200 university students (84 males and 116 females) from Shangrao Normal University were recruited for the validity assessment. Participants had a mean age of 21 years (SD = 1.48, 1.51). All participants received information about the study protocol and provided written informed consent. Ethical approval was granted by the Human Research Ethics Committee of Universiti Sains Malaysia (JEPem Code: USM/JEPem/KK/23030207). The study complied with the Declaration of Helsinki and was approved by the ethics committee of the Universiti Sains Malaysia.

Inclusion and exclusion criteria

The inclusion criteria for the study were that participants must be aged between 18 to 24 years, must be willing to participate, and must have no prior history of tobacco, alcohol, or drug use. Participants should also exhibit no signs of skin breakdown, redness, swelling, or bruising on the index finger. The exclusion criteria included individuals with a history of chronic neurological or psychiatric disorders, those with no history of diabetes or hypertension, female participants who

were menstruating at the time of the assessment, and individuals feeling unwell during the testing period. Participants were also informed that they can stop the study without any penalty.

Procedures

This study employed a structured research design incorporating both quantitative and qualitative elements. Initially, the two uniformly trained researchers (A&B) tested the 60 participants using the uBioMacpa Pro device. Measurements were conducted daily between 8 a.m. and 5 p.m. Before measurements commenced, participants' basic information, including names, gender, age, academic year, and contact details, was collected. During the assessment, participants were seated comfortably for approximately 2.5 minutes to measure the stress index. After a 10-minute interval, participants retaken the stress assessment under the guidance of Researcher B to ensure inter-rater reliability. This measurement procedure was repeated over three consecutive days to evaluate test-retest reliability while participants remained blinded of their measurement results throughout the process. Subsequently, the research team employed uBioMacpa Pro alongside the validated Chinese Stress Scale for College Students (C-SSCS) to evaluate the stress levels of college students in assessing concurrent validity. The flow diagram detailing the research procedure is illustrated in Figure. 1.

Insert Figure 1 here.

Figure 1 The flow diagram outlining the research procedure.

Measures

All participants were administered a socio-demographic checklist (name, sex, age, major, health status, etc.) and were measured by objective and subjective mental stress measuring tools, uBioMacpa Pro and Stress Scale for College Students (SSCS), respectively. Based on the research design, the research team conducted a concurrent validity test of uBioMacpa Pro with SSCS.

uBioMacpa device

The uBioMacpa Pro newly developed device was produced by BioSense Creative Inc., Seoul, Korea in 2023 (Figure 2). This innovative device was designed to measure accumulated stress levels. It measured heart rate variability (HRV) by analysing pulse waves to monitor vascular health and assess accumulated stress. The stress test offered two duration options: 2.5 minutes or 5 minutes. Typically, for testing accumulated stress, the test duration was set at 2.5 minutes.

To conduct the measurement, participants were instructed to sit with their backs against the chair for 5 to 10 minutes. Before the measurement commenced, the researcher checked the participants' heart rates to ensure they returned to normal levels. During the measurement, participants were instructed not to move, talk, or control their breathing, and to avoid intentionally taking deep or shallow breaths. Upon completion of the 2.5-minute measurement, the stress index was obtained by considering various data points, including pulse variation, heart rate distribution, autonomic nervous system balance, and detailed analysis.

The stress index was categorized into five groups: under 25 (good stress levels), 25-35 (temporary stress), 35-45 (primary stress), 45-60 (accumulated stress with diminishing stress

tolerance), and over 60 (chronic stress that necessitated medical attention). This device had been tested by BioSense Creative Inc. on over 20,000 Korean participants and demonstrated good validity and high measurement accuracy.

Insert Figure 2 here.

Figure 2. uBioMacpa Pro Measuring Probe

Chinese versioned Stress Scale for College Students (C-SSCS)

The Chinese versioned Stress Scale for College Students (C-SSCS) includes three sub-scales: study troubles, personal worries, and adverse life events. The C-SSCS contains 30 items rated on a 4-point Likert-type scale (0 = no stress to 4 = severe stress). It has a range of scores from 0 - 90, where a score of 45 or higher indicates high stress levels, and under 45 means low stress levels. The C-SSCS was developed by Lee & Mei (2002) and is a Chinese version of scale that has been widely used in China. The C-SSCS has demonstrated good reliability and validity, with Cronbach's alpha values of 0.91 for the whole scale and 0.88, 0.84, and 0.83 for the three subscales, and the test-retest reliability coefficient of the whole scale was 0.78 (Lee & Mei, 2002).

Statistical Analysis

All of the measured data were entered into Microsoft Excel, mainly including the mental stress scores measured by uBioMacpa Pro and questionnaire data. This study was analyzed utilizing SPSS 27.0 statistical software. Standard descriptive statistics would be used for all variables. Normal distribution measurement data were expressed as $M \pm SD$. $p < 0.05$ was considered statistically significant. The intraclass correlation coefficient (ICC) was used to assess retest and intra-rater reliability. Moreover, this study tested the correlation between uBioMacpa Pro and SSCS scores using Pearson correlation analysis to determine concurrent validity.

Results

Reliability test result

A total of 60 college students (30 males and 30 females) from Shangrao Normal University were recruited for this part of the study. Table 1 presents the participants' demographic characteristics, including age, gender, and grade. The average age was 20.91 (SD 1.48) years. About 38% of the participants were first-year students. All descriptive data were presented by mean score and standard deviation. To examine retest and inter-rater reliability, the ICC was calculated for different combinations of 3 measuring results of the same participant, as shown in Table 2.

- Insert Table 1 here.

- Insert Table 2 here.

The results of 3 consecutive days of measurement of the same subject by researchers A and B are shown in the table as A1, A2, A3, B1, B2, and B3. A and B represent the average of three

times the results for the same participant measured by researchers A and B, respectively. A1A2A3 was used to calculate the retest reliability ICC values by using the results of 3 measurements from Research A. A1B1 was used to calculate the inter-rater reliability ICC values using the first measuring results of Research A and B. Just as well AB represents the average of 3 times measuring results taken by two researchers on the same participant to determine inter-rater reliability.

From Table 2 above, we can see that test-retest reliability and inter-rater reliability are both high ($ICC > 0.75$). The inter-rater reliability ICC values calculated from the results of single inter-rater measurements were all above 0.85. In contrast, those calculated from the mean of three measurements were even higher ($ICC > 0.9$). Meanwhile, with test-retest reliability results, ICC values are all greater than 0.90, indicating excellent reliability.

Concurrent validity result

Two hundred volunteers (84 males and 116 females) aged 18 to 27 years (20.88 ± 1.51 ; means $\pm$ SD) were involved in this part of the study. There were more female students (116/200, 58%) than male students (84/200, 42%). Approximately 57% of the volunteers were junior and senior students. The mean uBioMacpa Pro stress index for the 200 participants was 31.31 (SD 11.09), and the mean SSCS score for the 200 students was 36.79 (SD 9.324). Table 3 contains the following essential characteristics.

- Insert Table 3 here.
- Insert Table 4 here.

Concurrent validity measures how a new test compares against a validated test. As described above, the C-SSCS has been validated. Therefore, our study utilized Pearson correlation analysis to evaluate the relationship between the uBioMacpa Pro stress index and C-SSCS scores. There was a significantly positive correlation between the uBioMacpa Pro and C-SSCS ($r = 0.246$, $p < 0.01$), as Table 4 shows.

Discussion

To the authors' knowledge, this is the first study to examine the reliability and validity of the psychological stress-measuring meter (uBioMacpa Pro) to measure psychological stress among Chinese university students. In the reliability study, the test-retest reliability and inter-rater reliability results of 3 consecutive days of measurement of the same subject by researchers A and B were both high ($ICC > 0.75$). The greater ICC values calculated using the mean of the three measuring results show that taking the mean value of the retest results is conducive to a higher confidence level. The two researchers who participated in this study were university students who had never used uBioMacpa Pro before and had only received a short training on it before the study. In comparison, their measuring results have good coherence. The result demonstrates that the uBioMacpa Pro used in this study is not only easy to use and portable but also reliable.

Subsequently, as for the validity study, we measured the psychological stress of college students by using uBioMacpa Pro and the Chinese versioned Stress Scales for College Students (C-SSCS) as a reference. The percentage of college students with high levels of mental stress using the C-SSCS scale accounted for 17% of all participants, whereas the proportion of high levels of mental stress measured by uBioMacpa Pro accounted for 19% of all students. The scale and the uBioMacpa Pro yielded similar results for measuring mental stress. Our study utilized Pearson correlation analysis to examine the relationship between the uBioMacpa stress index and SSCS scores to verify the uBioMacpa Pro concurrent validity. The results show that there was a significantly positive correlation between the uBioMacpa Pro and C-SSCS ($r = 0.246$, $p\text{-value} < 0.01$).

In scientific research, verification of reliability and validity is an essential step in ensuring the quality of measurement tools (Foxman, 2012). From what has been discussed above, the results of the reliability and validity study of uBioMacpa Pro indicate that it has good reliability and validity among Chinese college students. Thus, the uBioMacpa Pro could be used as a reliable measuring meter to assess psychological stress in a population of Chinese college students. Therefore, our study results are significant for Chinese universities' psychology management departments. Only with a better understanding of the psychological stress levels of college students can we more effectively address their psychological issues. Hence, how to keep track of college students' mental stress states is one of the most crucial issues. Meanwhile, it also offers Chinese researchers a reliable and standardized method for assessing psychophysiological conditions and stress indices in different populations. Its adherence to established guidelines and use of advanced technology make it a robust instrument for studies focusing on stress-related conditions and interventions.

Despite the immediate benefit of the instrument to mental health-relevant fields, the device's limitations should be noted. Several limitations exist in the measuring meter. For instance, uBioMacpa Pro would show a maximum or a minimum index during the measurement. If the respondents' finger temperature is too low, the stress index will show a '0' in the report. Alternatively, the uBioMacpa Pro will not display the accumulated stress index or relevant data for some girls with thin fingers or nail makeup. As a result, the usage of uBioMacpa Pro is constrained by certain environmental factors and conditions. Otherwise, the device will be unable to measure the relevant value, or the data will not be reliable. Hence, researchers should choose a good measuring environment and clarify whether the respondent has the exclusion criteria to obtain reliable data.

Conclusions

This paper conducted an in-depth study on the reliability and validity of the mental stress measuring meter, uBioMacpa Pro, using Chinese university students as the study population. The results of this study show that the uBioMacpa Pro has good reliability and validity. Therefore, the uBioMacpa Pro could be a reliable measurement instrument to monitor college students' mental stress states. For future research, the measurement procedures of mental health should be

standardized, and the accuracy of assessing psychological stress should be improved. In addition, uBioMacpa Pro should be validated in more studies and populations.

ADDITIONAL INFORMATION AND DECLARATIONS

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Competing Interests

The authors declare that they have no competing interests.

Author Contributions

- Mingzhu Pan conceived and designed the experiments, performed the experiments, analyzed the data, performed the computation work, prepared figures and/or tables, authored or reviewed drafts of the article, and approved the final draft.
- Xinxing Li conceived and designed the experiments, authored or reviewed drafts of the article, and approved the final draft.
- Solomon Gbene Zaata conceived and designed the experiments, prepared figures and/or tables, authored or reviewed drafts of the paper, and approved the final draft.
- Liying Yao performed the experiments, analyzed the data, prepared figures and/or tables, and approved the final draft.
- Yee Cheng Kueh conceived and designed the experiments, analyzed the data, performed the computation work, authored or reviewed drafts of the article, and approved the final draft.
- Garry Kuan conceived and designed the experiments, authored or reviewed drafts of the article, and approved the final draft.

Human Ethics

The study received approval from the Human Research Ethics Committee of Universiti Sains Malaysia (Jawatankuasa Etika Penyelidikan Manusia Universiti Sains Malaysia: JEPeM-USM) and followed all the regulation stated by the Declaration of Helsinki.

Data Availability

The following information was supplied regarding data availability:
The raw data is available in the Supplemental File.

Supplemental Information

Supplemental information for this article can be found online at [link](#).

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Table 1(on next page)

Table 1. Participant demographic characteristics

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Variables	M± SD	N(%)
Age	20.91±1.48	60(100%)
Male	21±1.44	30(50%)
Female	20.83±1.51	30(50%)
Freshman	-	23(38%)
Sophomore	-	5(9%)
Junior	-	18(30%)
Senior	-	14(23%)

*Note. M± SD=Mean± Standard deviation

Table 2 (on next page)

Table 2. Reliability test results (ICC, 95%CI)

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Table 2. Reliability test results (ICC, 95%CI)

	Test-retest reliability		Inter-rater reliability			
uBioMacpa Pro	A1A2A3	B1B2B3	A1B1	A2B2	A3B3	AB
	0.962	0.956	0.90	0.890	0.944	0.950
	0.9-0.97	0.9-0.97	0.9-0.95	0.85-0.95	0.9-0.95	0.9-0.97

Table 3(on next page)

able 3. Socio-demographic characteristics of the sample.

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Variables	M± SD	N(%)	Range
Age	20.88±1.51	-	18-27
Female	-	116(58%)	-
Male	-	84(42%)	-
Freshman	-	42(21%)	-
Sophomore	-	44(22%)	-
Junior	-	79(39.5%)	-
Senior	-	35(17.5%)	-
Mental stress (uBio)	31.31±11.09	200(100%)	19-64
Mental stress (SSCS)	36.79±9.324	-	10-52

*Note. Mental stress (uBio)= Mental stress index measured by uBioMacpa Pro; Mental stress (SSCS)=Mental stress score measured by SSCS scale.

Table 4(on next page)

Table 4. Correlation between uBioMacpa Pro & SSCS

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Table 4. Correlation between uBioMacpa Pro & SSCS			
	M± SD	uBioMacpa Pro (r, <i>p</i>)	SSCS (r, <i>p</i>)
uBioMacpa Pro	31.31±11.09	1	0.246, <i>p</i> <0.01
SSCS	36.79±9.324	0.246**, <i>p</i> <0.01	1

2

3

Figure 1

Figure 1 The flow diagram outlining the research procedure.

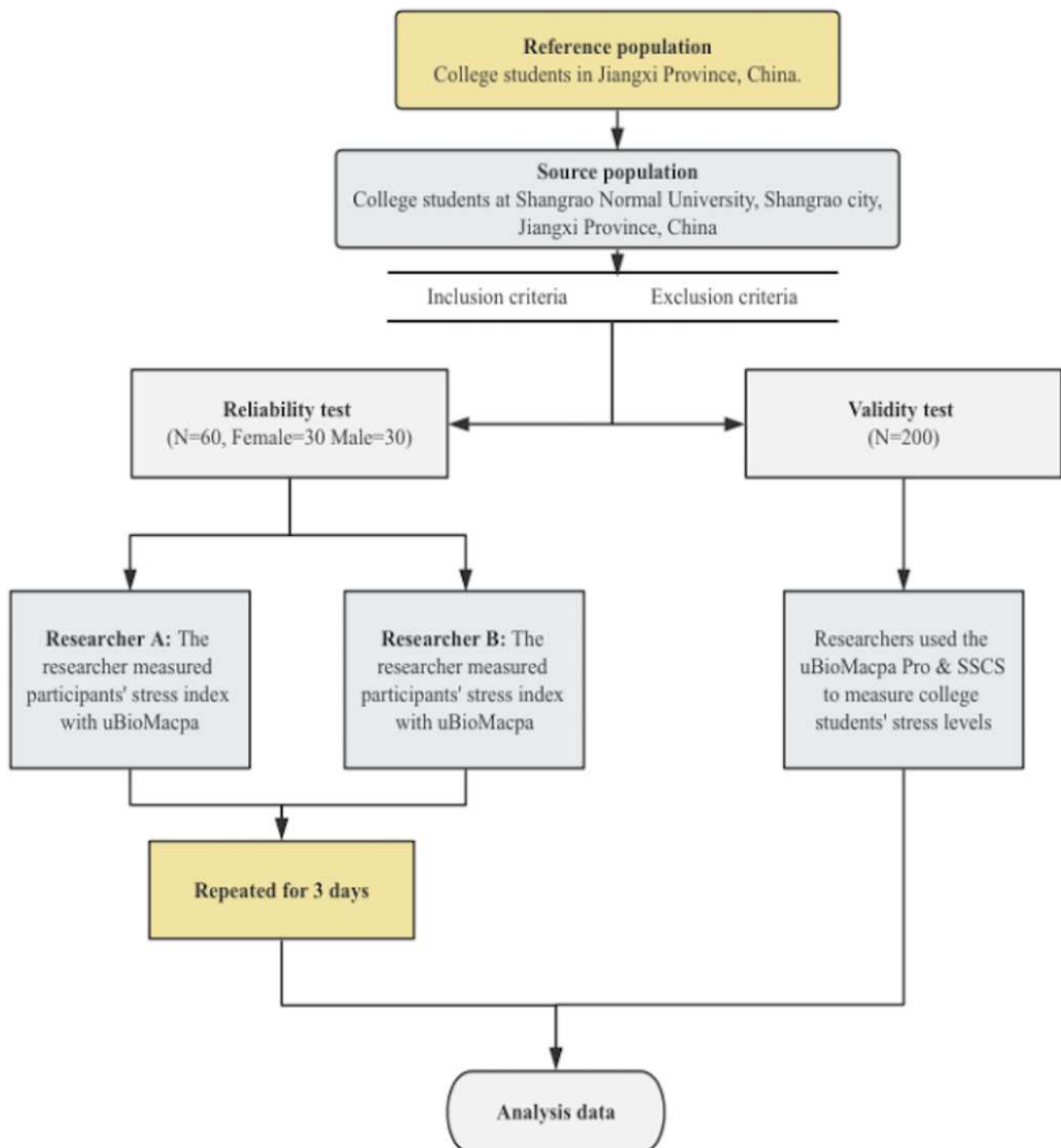


Figure 2

Figure 2. uBioMacpa Pro Measuring Probe

