University of Thessaly

Department of Physical Education and Sport Science

Validity of non-invasive body temperature measurements in comparison to esophageal temperature during rest, exercise and recovery under hot and neutral environments.

Εγκυρότητα μη παρεμβατικών μετρήσεων θερμοκρασίας σώματος σε σχέση με την θερμοκρασία οισοφάγου σε ηρεμία, άσκηση και την αποκατάσταση σε θερμό και ουδέτερο περιβάλλον.

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February 2025

Prologue

This undergraduate thesis was fulfilled as part of my undergraduate studies at the Department of Physical Education and Sport Science of the University of Thessaly. The study was conducted in collaboration with the environmental physiology laboratory "FAME Lab", under the supervision of Dr. Andreas Flouris. Firstly, I want to thank Dr. Andreas Flouris for letting me fulfil my undergraduate thesis experiment in Fame Lab and guiding me throughout the hole process as well as for sparking an intrigue for science and research me. Without him I would not be where I am now. I also would like to thank Vivi Gkiata for training me and providing much needed assistance. Special thanks go to Maria Vliora for helping me through out all the stages of my experience in the lab and her general support and patience. I want to thank all the people who accepted to be participants in my study and underwent hardship in the name of science. Lastly, I want to thank the special people in my life, my Family and friends who supported me unconditionally.

"One must imagine Sisyphus happy" – Albert Camus

To those who made me realize that doing difficult things can make me happy.

Chapters

7. Appendix

0.1. Abstract

The purpose of this study was to find the validity and reliability of non-invasive temperature measuring sensors in measuring core temperature (Tc), compared with the invasive gold standard esophageal sensor in a neutral and hot environment during rest, exercise and recovery. The sensors specifically tested were: Axillary mercury and electronic thermometer, temporal infrared thermometer, acoustic membrane thermometer and Calera research heat flux wearable device. To do this an experimental protocol was constructed. The protocol consists of three phases. Phase 1 lasts 24 minutes where the subject will be in a resting state sitting on a chair, phase 2 lasts 20 minutes and consists of the exercise protocol where the subject will be called to exercise at an intensity of 60% of the maximum heart rate, adjusted for age according to the Karvonen equation (Target Heart Rate = [(max HR − resting HR) × %Intensity] + resting HR) (1) on a static cycle ergometer. The last part of the experiment Phase 3 consists of the recovery phase, where the subject will stop the exercise and will be rested for 20 minutes. This concludes the experimental protocol which will be repeated 2 times for each subject. Once In a neutral environment (Trial 1: temperature 23-24°C, relative humidity 60%) and the other in a hot environment (Trial2: temperature 34-35°C, relative humidity 60%). Throughout the experimental protocol temperature readings were taken simultaneously with the gold standard. The study concluded that out of all the sensors only axillary thermometer was overall valid and reliable to be used in all setting to measure Tc compared with oesophageal sensor mean difference (MD) within ±0.3 of oesophageal values, Pearson r: 0.60.

1. Introduction

A significant amount of the modern population is being affected by higher environmental temperatures and or heat-related illnesses. This can be contributed to climate change and heat waves which have been more recent worldwide (2, 3) There is requirement of many occupations to work under intense temperatures (4). Such examples are agriculture and construction workers, who are the two groups more commonly associated with heat related deaths 35 and 13 times more likely than workers from other industries (5, 6). Also, many athletic events take place in non-ideal environmental temperatures (7, 8) and athletes who are expected to perform in these conditions can be harmed. These new

challenging circumstances have urged the need for ways to predict and prevent heat stress like the use of proper hydration, protective and task specific clothing and heat acclimation-acclimatization (9). Although these methods can be helpful it is of equal importance to develop and validate methods and tools to measure Tc for the prevention of heat stress and heat related illness (10, 11). The most accurate method to acquire Tc is with the use of intrusive sensors like the pulmonary artery, esophageal and rectal sensors (12, 13). Although these sensors are reliable, they cannot be realistically used outside a hospital or laboratory environment (14). The body temperature sensors used as household items are noninvasive, inexpensive and publicly available such as auxiliary electronic and mercury thermometers, infrared temporal thermometer and infrared acoustic thermometer. Despite their convenience and availability these sensors are not very accurate in measuring Tc in stress conditions like exercising.(15). Although, the mercury axillary thermometer which has shown accuracy when compared with invasive sensors (16) and it has proven to be more reliable than its electronic counterpart (14) there have not been many studies testing its accuracy and validity in an exercise setting. Meanwhile, there has been a decrease in its use due to concerns regarding maintenance and safety hazards. Recently many types of sensors have made an appearance in the market like the wearable thermal monitor sensors(Saidi and Gauvin 2023),these devices are marketed to recreational and professional athletes and for workers for tracking down their temperature in real time. One of these devices is the CALERA® Research device, a heat-flux sensor targeted towards athletes which incorporates a thermal energy transfer sensor. CALERA research has been used in a few studies where deficiencies in accuracy and validity were observed(15, 17).The aim of this study is to validate noninvasive Tc sensors with the reliable esophageal sensor during rest, exercise and recovery under different environmental conditions inside an environmental chamber.

2. Literature

2.1 Exercise in non-ideal circumstances

In a recent study (8), it was observed that Pic performance of athletes competing in endurance events was calculated to a WBGT between 7.5°C and 15°C. At the same time 26% of the races were conducted in moderate, high and extreme heat conditions which exceeded the ideal circumstances parameters. The study also confirmed that when events took place under higher environmental temperatures it negatively affected the performance of athletes. Although there are some groups of people who are specifically susceptible to heat illnesses, even young and

healthy individuals are at risk of heat stress when engaging in strenuous outdoor physical activities during hot weather conditions (18).

2.2 Rise of environmental temperature

The rise of environmental temperatures is a phenomenon which affects the population worldwide. 2024 was the warmest year on record(19) proving this point, the global average temperature between 2014 to 2023, is estimated to be the highest 10-year period on record, being 1.2°C above the 1850-1900 average(20), affirming the consensus that there is a progressional rise of global environmental temperature and climate change is an undisputed existing effect. Moreover, there has been an apparent rise in the duration of heatwaves in data collected by 48 US states, a rise in warm days has been observed in a calendar year and colder nights have been decreased. (1)

2.3 Heat-related illness

Heat related illness (HRI) also known as hyperthermia is a condition in which Tc is raised beyond normal which is ~37°C, at rest and ~38°C, during moderate-intensity (21) Heat stress can occur with the combination of different circumstances, This includes exposure to a high degree of environmental temperature, external heat load, production of metabolic heat that cannot properly be expelled (internal heat),(21, 22). The inability of the organism to keep the Tc within the homeostatic norm under can result in the development of heat related illnesses or HRIs (22).Heat related illness include: Heat edema, Heat cramps, Heat syncope, Heat tetany, Heat rash, Heat exhaustion, Heat stroke, all of which have a variety of symptoms.(23).

2.4 Exercise induced hyperthermia

The inability of the body to expel heat during the production of work derived from active muscular actions and the subsequent elevation of Tc beyond normal levels and leads to hyperthermia or exertional heat illness (21, 24) this can affect both the peripheral and central nervous systems leading to nervous system fatigue,(25). The body also gets dehydrated through the process of sweating and vasodilation witch under prolonged time drain body fluids and produce cardiovascular strain (26) and neuromuscular fatigue (27). During elevated Tc 38.5°C - 40°C the shared need for blood flow between skeletal muscles, vital organs and the skin gets overbearing for the human body. Subsequently the cardiac output fails to fulfill the needs of all the tissues leading to heat exhaustion(9).

2.5 Heat related occupational hazards

In a meta-analysis that was published (6) its stated that for most occupations working in conditions over 25C raises the risk for heat strain. The study also reveals that workers occupied in heat stress conditions were four times more likely to experience occupational heat strain during or after a work shift compared with individuals working in thermoneutral conditions. The occupations are not specific, HRIs have been linked with both indoor and outdoor occupations. Although non-fatal incidents of HRIs can sometimes be overlooked by workers and personnel and subsequently go unrecorded the supporting data from North Carolina, collected from 2008-2010 shows that occupational HRIs resulted in more trips to the emergency room compared to any other work-related cause among patients of 19-45 years (28). To further link the rise of environmental temperature with the engagement of workers in the state Washington it was observed that the rise of even 1 °C increase in maximum humidity index (humidex) was associated with increase of traumatic injuries(28) there has also been identified a strong correlation between a higher rate of HRI in the third quarter and hotter summers(29). Furthermore, HRIs are the most common health effects experienced by agricultural workers as a result of their prolonged exposure to high temperatures (3).

2.6 Heat-related deaths in general population, sports and occupation

According to the NATIONAL WEATHER SERVICE for the year 2023 (US Department of Commerce), in the US 207 deaths were attributed to heat. This number is higher than the 10-year average of 2014 to 2023 which is 188 it is also the highest number of any other environmental cause of death for that year. Moreover global warming has contributed to a rise of lethal environmental illnesses such as ischemic heat stroke (30) and extreme heat levels have been linked with various deaths from people who suffer from cardiovascular diseases such as hypertension, diabetes, hyperlipidemia, and coronary artery disease (31). Athletes often experience thermal stress which results in exertional heat stroke being in the top three causes of mortality for athletes in the US (32). It also accounts for 2% of all sport-related deaths (33) and specifically 15% of all football deaths annually (34). Many occupations have very high demands regarding physical labor which paired with extreme heat can be lethal. Between 2010 and 2012 in the United States of America 13 deaths were attributed to heat exposure while in a workplace environment (35). When talking about occupational mortality due to heat It is important to mention the paradigm of the construction worker. Specifically, between 1992 and 2016 258 construction workers were pronounced dead caused by heat exposure, of which 75% occurs when environmental temperatures rise during the summer (36). Another occupation which is very susceptible to heat mortality is that of agricultural workers. Agricultural workers experience very high environmental temperatures and endure physically straining work in a daily basis.

For these reasons Heat related deaths in agricultural workers are 35 times above the average worker (37).

2.7 Core and Peripheral temperature differences

Body temperature has different values throughout the human body. Therefore, we categorize the body in two groups regarding the surface the measurement is extracted from. The first group is the external shell temperature. The sight of its measurements being the skin also known as peripheral body temperature which is observed to rapidly change temperature. Moreover, we have the second group, the internal core temperature known also as Tc, the sight of its measurements being subcutaneous and, or internal body surfaces. Tc measurements are generally more stable (38). The center of thermoregulation resides within the human brain in the preoptic area of the hypothalamus. The function of the hypothalamus is to analyze stimuli that comes from the different temperature sensors located all over the human body and react to achieve thermal homeostasis (39).The thermal sensors in the human body are called thermoreceptors. They consist of the peripheral thermoreceptors located on the skin and the internal thermoreceptors located in the brain, viscera and spinal cord. Peripheral thermoreceptors perceive external thermal stimuli whereas internal thermoreceptors perceive Tc changes. In case these receptors discern divergence of temperature using the Central and Peripheral Nervous systems the signal will notify the hypothalamus which in turn will react accordingly to the stimuli provided. Subsequently, the mechanisms of thermoregulation will be utilized with the goal of reinstating homeostasis (39). Changes in skin (Peripheral) temperature do not always associate with changes in Tc , the former can be a result of rapid differences of environmental temperature. (40) Even if Tc does not fluctuate the perceived change in body temperature by peripheral thermoreceptors can lead to the enabling of physiological thermoregulatory responses for the pre-emptive maintenance of internal temperature. For this reason, it is categorized as feedforward mechanism(41).

2.8 Invasive and noninvasive sensors

As it stands the influence of environmental temperature plays a big role in the lives of most people (42) and can have many negative effects especially regarding public health (43). For this reason measurement of Tc is defining for preventing HRIs and temperature monitoring during strenuous activity (44). Many thermal sensors are used by medical professionals and the public to assess body temperature. These sensors are subsequently divided into two categories regarding where in the human body they need to be placed to subtract

temperature readings. Firstly, non-invasive sensors. These sensors extract data by distance, or by contact without the need of penetrating the skin. Secondly, the invasive sensors. These are placed inside the human body and derive readings directly from internal body surfaces (45). Non-invasive sensors although easier and more comfortable to use do not wield readings that are as accurate as noninvasive sensors (13, 46) especially during exercise (47)

The most precise Tc measurement is through the use of the Swan-Ganz catheter the site of the measurement being the pulmonary artery although this method is regarded as the Gold standard it is only possible to use trough surgery (13, 48, 49). The next site of Tc readings that is considered to give very accurate information is the digestive system. Including, oral, esophageal, gastrointestinal, and rectal surfaces. Esophageal sensors are regarded as very accurate in depicting Tc,(50, 51). Rectal temperature sensor corelates with pulmonary artery and is considered to give accurate readings of Tc. Although not with the same accuracy as the esophageal due to a latency in the depiction of temperature fluctuation has been observed with the rectal sensor (13, 52). Lastly oral thermometers have been observed to not give accurate readings for Tc (53). The next site of temperature measurement regarding accuracy is the head. Temporal thermometers have shown to not depict accuracy in measuring Tc in exercise and clinical settings (15, 54). The tympanic membrane thermometer is regarded as a good device for Tc measurement when the device is in direct contact with the tympanic membrane(55). For this to be possible a well-trained individual needs to be present and the accuracy drops when using an infrared tympanic membrane thermometer (56-59), still wields more accurate results than other noninvasive sensors(60). The least reliable site to gain information about temperature is the surface of the skin. The reason for the bias can be explained by skin being in direct contact with the environment. Therefore, its temperature fluctuates throughout the body.(61, 62). The main thermometers used to derive temperature from skin surface are auxiliary thermometers which have shown to not give accurate Tc readings in medical and exercise settings (15, 63).

2.9 Wearable thermal monitoring devices

With the advancement of technology, health and performance monitoring tools have been altered to support wearable real time monitoring functions. One notable example includes heart rate monitors in smart watch devices. Similarly, many companies have made the effort of producing a wearable temperature measuring sensor that would be of practical use for athletes' workers and the general public for the purpose of tracking Tc in real time during activity. Although this seems to be the direction of temperature monitoring, the ability of wearable sensors to provide accurate Tc readings during exercise is mixed.(17, 64-69)

3. Methods-Materials

3.1 Chamber

Both Trials took place inside an environmental chamber. This chamber is housed in the Environmental Physiology Laboratory of SEFAA of the University of Thessaly in Trikala.

3.2 Sample Size

This study was directed toward a general population consisting of 9 individuals who do not have any health problems. The minimum required sample size for conducting the study was calculated using the G*Power program and data from a previous study (Verdel et al., 2021), in which various measurements were obtained in both hot and neutral environments comparing the CARELA sensor with rectal temperature. All participants signed an informed consent form.

3.3 Participants

The participants where 7 males and 2 females all volunteers were athletic and healthy. The Mean for age was 25 with a Standard deviation of ±8 years.

3.4 Cardiac Frequency Recording and Heart Rate Variability

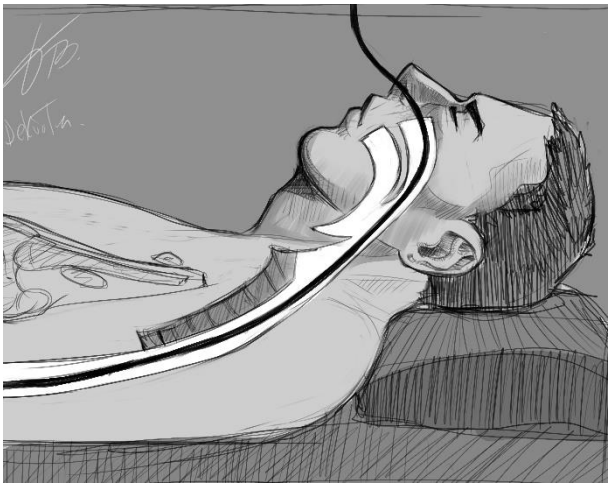
Specifically, the volunteers wore an elastic chest strap that transmits heart rate data via short-range telemetry at 1,000 Hz to a Polar watch (model RS800CX or V800 PolarElectro, Kempele, Finland). The data were transmitted via the Polar Flow application to a computer for subsequent analysis and evaluation of heart rate variability.

3.5 Height and Weight

Specifically, height will be recorded to the nearest centimetre. Weight will be measured with an accuracy of up to 0.001 kg using a precision scale (KernDE 150K2D, KERN & SOHN GmbH, Balingen, Germany).

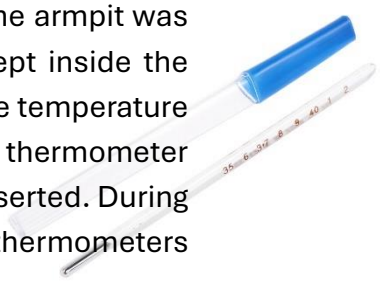
3.6 Esophageal Temperature

Due to its high confirmed reliability and validity to measure Tc oesophageal sensor was selected to be used as gold standard for this study (50, 51). Specifically, esophageal temperature will be recorded using an esophageal sensor (Mon-a-Thermgeneral purposes probe), which is a thin, flexible tube provided to the volunteer in a sealed and sterilized package. The esophageal probe is coated with a special lubricant. The volunteer inserts the probe through the nasal cavity toward the back of the throat. This is followed by swallowing a small amount of water using a straw to close the tongue, thereby allowing the probe to slide down into the esophagus. The probe is positioned at approximately the level of the laryngeal prominence and its insertion length is based on the regression equation of Mekjavic & Rempel: Insertion Length (cm)=0.479×(standing height)−4.44(71). The temperatures will be recorded via a portable unit connected to the sensor and stored on a computer.



3.7 Axillary temperature with Mercury Thermometer

Axillary temperature was measured using a mercury thermometer. The measurement was performed in the volunteer's left armpit while the armpit was kept closed. More specifically, the thermometer needed to be kept inside the participants armpit for 4 minutes (72) in order to ensure an accurate temperature measurement. For this to be possible every 4 minutes one mercury thermometer would be removed and simultaneously another would have to be inserted. During the experimental protocol in hot environment (Trial 2) the mercury thermometers



would be situated outside the environmental chamber so that there would not be complications.

3.8 Axillary temperature with Electronic Thermometer

Axillary temperature was measured using the Biopharm Metricy Classic DT-01D Digital Thermometer. The measurement was performed in the volunteer's right armpit while the armpit was kept closed. More specifically the electronic thermometer would be inserted at the 3rd minute of the mercury thermometers measurement and was removed when it made the distinctive sound roughly at the same time as the mercury thermometer. This ensured that both thermometers were operating at the same time. During the experimental protocol in the hot environment (Trial 2) the thermometers were situated outside the chamber to cool down.

3.9 Acoustic membrane temperature.

Acoustic membrane temperature was measured using the Microlife IR 150 infrared ear thermometer, which by emitting infrared radiation can evaluate the temperature of the eardrum and surrounding tissues. Per measured there will be three repetitive readings taken in the volunteer's left ear, and the highest value was recorded. To perform the measurement, the ear was gently pulled back to straighten the ear canal. The probe of the thermometer was inserted into the left ear canal and activated subsequently a temperature reading was obtained. The measurement took place between the 3rd and 4th minute of the mercury thermometer measurement and was removed when it made the distinctive sound roughly at the same time as the mercury thermometer. Before the experimental

protocol in a hot environment (Trial 2) The thermometer would be kept inside the environmental chamber for 20 mins so the device would reach thermal equilibrium.

3.10 Temporal Temperature

Temporal temperature readings were measured using the BRAUN-BTN400CA No Touch Forehead Infrared thermometer, which evaluates the infrared radiation emitted by the forehead and surrounding tissues. To ensure proper measurement, the sensor needed a small distance approximately 2 cm from the volunteer's forehead. The measurement took place between the 3rd and 4th minute of the mercury thermometer measurement and was removed when it made the distinctive sound roughly at the same time as the mercury thermometer. The thermometer would stay inside the environmental chamber prior to the experiment to reach thermal equilibrium.

3.11 CALERA research sensor:

The CALERA Research sensor is a portable, non-invasive device used for measuring core body temperature, developed by greenTEG A.G., based in Rümlang, Switzerland. It uses a thermal energy transfer sensor that is placed on the skin to collect data. According to the manufacturer, its design is similar to the CORE sensor, but the CALERA Research sensor offers additional features tailored for research applications. Data from the device is stored on an electronic device using the Calera – Core Body Temperature application. The CALERA research sensor was calibrated using the personal anthropometric measurements of the volunteer, after that the sensor would be attached on the left side of the volunteers' ribs on the height of the heart. The CALERA sensor would be

connected to a phone and give measurement readings live through the Calera – core body temperature app.

3.12 Study Design

Participants will be invited to visit the Environmental Physiology Laboratory of SEFAA at the University of Thessaly in Trikala three times. On the first visit, volunteers will complete the questionnaire (see Appendix), undergo anthropometric measurements, and become familiar with the experimental protocol, after that two different meetings will be arranged with at least 48 hours between the two experimental protocols.

3.13 Experimental session

When the subject is deemed ready, all measurement devices will be attached and then start the experimental session of the study. The experiment consists of three phases. Phase 1 lasts 24 minutes were the subject will be in a resting state sitting on a chair, phase 2 lasts 20 minutes and consists of the exercise protocol where the subject will be called to exercise at an intensity of 60% of the maximum heart rate, adjusted for age according to the Karvonen equation (Target Heart Rate = [(max HR − resting HR) × %Intensity] + resting HR) (1) on a static cycle ergometer. The last part of the experiment Phase 3 consists of the recovery phase, where the subject will stop the exercise and will be rested for 20 minutes. This concludes the experimental protocol which will be repeated 2 times for each subject. Once In a neutral environment (Trial 1: temperature 23-24°C, relative humidity 60%) and the other in a hot environment (Trial2: temperature 34-35°C, relative humidity 60%). Throughout the experimental protocol temperature readings will be taken simultaneously with the gold standard oesophageal sensor (ESOPH) by other non-invasive temperature monitoring sensors in different body sites. The mercury (MERC) and electronic (ELEC) axillary thermometer will be used for axillary temperature readings, temporal infrared thermometer (TEMP) will be used for forehead readings, acoustic membrane infrared thermometer (ACOUST) will be used for aural readings. Finally, the Calera sensor (CALERA) although can be used

in many surfaces around the body's circumference it will be placed on the left side of the subject's thorax.

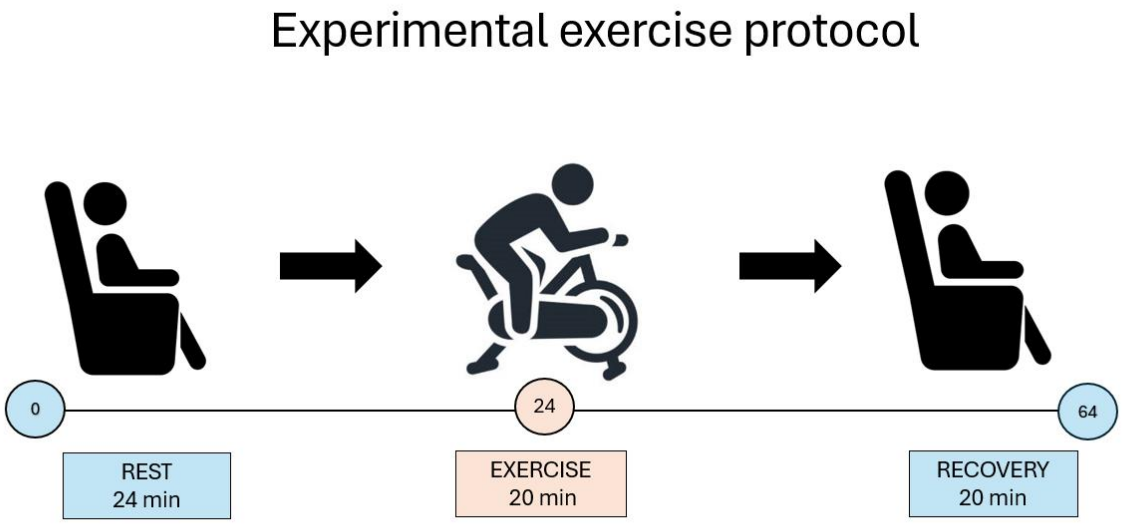


Table 1. Experimental protocol

3.14 Statistical analysis

For the statistical analysis the software used was IBM SPSS Statistics Version 29 and Microsoft Excel, Version 2024.

Pearson Correlation Coefficient: Pearson's correlation coefficient (r) was used to evaluate the reliability between the esophageal sensor and every other sensor.

Paired t-test: The paired t-test was employed to assess systematic differences between the measurements from the noninvasive sensors and the esophageal sensor to compare the accuracy and subsequently the validity of measurements between the other sensors with gold standard sensor.

The mean difference (MD) is calculated by pared t-test esophageal mean – non-invasive sensor = MD. Subsequently when the value is positive (+) the non-invasive sensor undervalues Tc while a negative value (-) overestimatesTc. For the accuracy of the sensor the cutoff was placed at ±0.3 similar to other studies of the same nature(15, 17, 70) in our study a sensor would be considered accurate if MD was within ±0.3

4 Results

Phase	Trial 1 Mean ± SD (°C)	Trial 2 Mean ± SD (°C)
Phase 1	36.76 ± 0.16	36.77 ± 0.18
Phase 2	37.04 ± 0.29	37.06 ± 0.30
Phase 3	36.93 ± 0.26	37.05 ± 0.24

Table 2. Mean and SD for esophageal!

Sensor	Pearson r
MERC	0.60 (Moderate)
ELEC	0.64 (Moderate)
TEMP	0.64 (Very Weak)
ACOUST	0.35 (Weak)
CALERA	0.09 (Very Weak)

Table 4. Pearson r, overall, for all sensors.

	Pearson r	
Sensor	Trial 1	Trial 2
MERC	0.51 (Moderate)	0.71 (High)
ELEC	0.53 (Moderate)	0.75 (High)
TEMP	-0.10 (Very Weak)	0.08 (Very Weak)
ACOUST	0.35 (Weak)	0.64 (Moderate)
CALERA	0.06 (Very Weak)	0.13 (Very Weak)

Table 3. Pearson r, for Trial 1 and Trial 2

TRIAL 1										
	Phase	Mean (°C)	SD (°C)	Pearson r	Mean Diff (°C)	Mean Diff SD (°C)	Effect Size d	LoA (°C)	CV	cutoff (±0.3°C)
Mercury Axillary Thermometer	Phase 1	36.70	±0.31	0.24 (Low)	+0.06	±0.31	0.25 (Small)	0,06±0.61 (Wide)	0.84 (Low)	pass
	Phase 2	37.23	±0.29	0.40 (Moderate)	–0.03	±0.41	–0.09 (None)	0.03±0.80 (Wide)	1.10 (Moderate)	pass
	Phase 3	37.27	±0.27	0.57 (Moderate)	–0.08	±0.31	–0.18 (None)	0.08±0.62 (Wide)	0.85 (Low)	pass
Electronic Axillary Thermometer	Phase 1	36.38	±0.23	0.02 (Very low)	+0.38	±0.25	1.98 (Large)	0,38±0.50 (Wide)	0.69 (Low)	fail
	Phase 2	36.59	±0.36	0.43 (Moderate)	+0.45	±0.35	1.36 (Large)	0.45±0.69 (Wide)	0.96 (Low)	fail
	Phase 3	36.61	±0.34	0.66 (High)	+0.31	±0.26	1.08 (Large)	0.31±0.51 (Wide)	0.71 (Low)	fail
Temporal Thermometer	Phase 1	36.40	±0.48	0.15 (Very low)	+0.36	±0.48	1.06 (Large)	0,36±0.9 (Wide)	1.32 (Moderate)	fail
	Phase 2	36.21	±0.63	–0.21* (Low)	+0.83	±0.75	1.68 (Large)	0.83±1.46 (Wide)	2.04 (High)	fail
	Phase 3	36.08	±0.57	0.09 (Very low)	+0.84	±0.61	1.85 (Large)	0.84±1.19 (Wide)	1.66 (High)	fail
Aoustic Membrane Thermometer	Phase 1	35.43	±0.50	0.17 (Very low)	+1.33	±0.50	3.78 (Large)	1.33±0.98 (Wide)	1.38 (Moderate)	fail
	Phase 2	35.74	±0.60	0.26 (Low)	+1.30	±0.59	2.76 (Large)	1.30±1.16 (Wide)	1.63 (High)	fail
	Phase 3	35.59	±0.52	0.42 (Moderate)	+1.33	±0.47	3.14 (Large)	1.33±0.93 (Wide)	1.31 (Moderate)	fail
Calera Thermometer	Phase 1	37.22	±0.44	–0.08* (Very low)	–0.46	±0.48	–1.39 (Large)	0.46±0.94 (Wide)	1.30 (Moderate)	fail
	Phase 2	37.16	±0.51	0.17 (Very low)	–0.12	±0.55	–0.33 (Small)	0.12±1.07 (Wide)	1.47 (Moderate)	pass
	Phase 3	37.35	±0.57	0.08 (Very low)	–0.42	±0.61	–0.96 (Large)	0.42±1.19 (Wide)	1.64 (High)	fail
TRIAL 2										
	Phase	Mean (°C)	SD (°C)	Pearson r	Mean Diff (°C)	Mean Diff SD (°C)	Effect Size d	LoA (°C)	CV	cutoff (±0.3°C)
Mercury Axillary Thermometer	Phase 1	36.84	±0.26	0.33 (Low)	–0.08	±0.26	–0.36 (Small)	0.08±0.5 (Wide)	0.71 (Low)	pass
	Phase 2	37.23	±0.29	0.78 (High)	–0.17	±0.20	–0.56 (Medium)	0.17±0.39 (Wide)	0.54 (Low)	pass
	Phase 3	37.27	±0.27	0.57 (Moderate)	–0.22	±0.24	–0.83 (Large)	0.22±0.46 (Wide)	0.64 (Low)	pass
Electronic Axillary Thermometer	Phase 1	36.47	±0.27	0.40 (Moderate)	+0.29	±0.26	1.29 (Large)	0.29±0.51 (Wide)	0.70 (Low)	pass
	Phase 2	36.86	±0.34	0.79 (High)	+0.20	±0.21	0.62 (Medium)	0.20±0.42 (Wide)	0.58 (Low)	pass
	Phase 3	36.92	±0.26	0.69 (High)	+0.13	±0.20	0.54 (Medium)	0.13±0.39 (Wide)	0.53 (Low)	pass
Temporal Thermometer	Phase 1	36.22	±0.56	0.06 (Very low)	+0.55	±0.58	1.38 (Large)	0.55±1.13 (Wide)	1.59 (High)	fail
	Phase 2	36.30	±0.44	0.19 (Very low)	+0.76	±0.48	2.01 (Large)	0.76±0.94 (Wide)	1.31 (Moderate)	fail
	Phase 3	35.90	±0.48	0.21 (Low)	+1.15	±0.48	3.08 (Large)	1.15±0.95 (Wide)	1.33 (Moderate)	fail
Aoustic Membrane Thermometer	Phase 1	36.67	±0.33	0.43 (Moderate)	+0.10	±0.30	0.38 (Small)	0.10±0.59 (Wide)	0.82 (Low)	pass
	Phase 2	37.00	±0.37	0.57 (Moderate)	+0.06	±0.32	0.18 (None)	0.06±0.62 (Wide)	0.86 (Low)	pass
	Phase 3	36.98	±0.35	0.64 (High)	+0.07	±0.27	0.24 (Small)	0.07±0.53 (Wide)	0.73 (Low)	pass
Calera Thermometer	Phase 1	37.19	±0.33	0.04 (Very low)	–0.42	±0.37	–1.59 (Large)	0.42±0.73 (Wide)	1.00 (Low)	fail
	Phase 2	37.16	±0.39	0.21 (Low)	–0.10	±0.44	–0.29 (Small)	0.10±0.87 (Wide)	1.20 (Moderate)	pass
	Phase 3	37.45	±0.41	–0.06* (Very low)	–0.40	0.49	–1.21 (Large)	0.40±0.96 (Wide)	1.32 (Moderate)	fail

Table 5. Phase 1,2,3 all data for Trial 1 and Trial 2

Table 2. Depicts mean and SD readings for esophageal sensor during Trial 1 and **Trial 3.** Depicts the absolute Pearson r values between esophageal and non-invasive thermometers (all Phases and both trials combined). **Table 4.** Depicts Pearson r values between esophageal sensor and noninvasive thermometers separately for Trial 1 and Trial 2 with all phases combined. **Table 5.** Depicts analytically all data for every Phase separately (Phase 1, Phase 2, Phase 3) under each trial (Trial 1 and Trial 2) separately. All data provided further comes from **Table 2. Table 3. Table. 4 and Table. 5**.

4.1 Mercury Axillary Thermometer

Under neutral environmental conditions In Trial 1, MD were minimal, Phase 1: +0.06°C, Phase 2: +0.03°C, and Phase 3: –0.08°C. Making the thermometer be well within the accuracy threshold (MD of ±0.3C° accordingly). SD, Phase 1: ±0.31, Phase 2: ±0.29, Phase 3: ±0.27.The corresponding effect size Phase 1: 0.25, Phase 2: –0.09, and Phase 3: –0.18 were considered small, Pearson r values ranged from Phase 1: 0.24 (low), Phase 2: 0.40 (Moderate), Phase 3: 0.57 (Moderate) showing increase in correlation with rise of internal temperature due to exercise. Mean

difference standard deviation (MDSD) of Phase 1: ±0.31°C, Phase 2: ±0.41°C, and Phase 3: ±0.31°C are regarded low and coefficients of variation (CV) ranging from low to moderate, Phase 1: 0.84 (Low) Phase 2: 1.10 (Moderate) Phase 3: 0.85 (Low).

In Trial 2 (35°C), despite the elevated ambient temperature, MD remained low Phase 1: –0.08°C, Phase 2: –0.17°C, Phase 3: –0.22°C again, making it eligible for accuracy (±0.3°C). SD, Phase 1: ±0.26, Phase 2: ±0.29, Phase 3: ±0.27. The effect size (d) had a wide range from Phase 1: –0.36 (small) Phase 2: -0,56 (medium) and Phase 3: –0.83 (large) thus showing some statistically significant differences compared to gold standard when internal temperature is rising due to exercise Pearson (r) values ranged from Phase 1: 0.33 (Low), Phase 20.78 (High), and Phase 3: 0.57 (Moderate) again correlation was higher when internal temperature increased due to exercise. Similarly, (MDSD) decreased Phase 1: ±0.26, Phase 2: ±0.20, Phase 3: ±0.24, CV also had low values Phase 1: 0.71 (Low) Phase 2: 0.54 (Low) Phase 3: 0.64 (Low). In both Trials Limits of agreement, (LoA) were wide. Trial1: 0,06±0.61(Wide),0.03±0.80 (Wide),0.08±0.62 (Wide). Trial 2 :0.08±0.5 (Wide), 0.17±0.39 (Wide), 0.22±0.46 (Wide).

4.2 Electronic Axillary Thermometer

In Trial 1, MD was insufficient, Phase 1: +0.38, Phase 2: +0.45, Phase 3: +0.31, with Phase 3 barely exceeding the cutoff for sensor accuracy (±0.3°C). MDSD was low Phase 1: ±0.25, Phase 2: ±0.35, Phase 3: ±0.26. SD: Phase 1: ±0.23, Phase 2: ±0.36, Phase 3: ±0.34. Large effect sizes were observed Phase 1: 1.98, Phase 2: 1.36, and Phase 3: 1.08 and r values spanning from very low Phase 1: 0.02 to moderate Phase 2: 0.43 and high Phase 3: 0.66. Underscoring a moderate level of variability relative to the esophageal sensor. and CV was found low Phase 1: 0.69 (Low), Phase 2: 0.96 (Low), Phase 3: 0.71 (Low).

In contrast, in Trial 2, the sensor's performance improved under all three Phases with MD decreasing in all Phases, Phase 1: +0.29, Phase 2: +0.20, Phase 3: +0.13, all are below cutoff (±0.3°C). MDSD also decreased, Phase 1: ±0.26, Phase 2: ±0.21, Phase: 3 ±0.20. SD: Phase 1: ±0.27, Phase 2: ±0.34, Phase 3: ±0.26. Still effect size increased Phase 1: 1.29 (Large), Phase 2: 0.62 (Medium-sized), Phase 3: 0.54 (Medium-sized), showing better agreement when internal temperature is rising during exercise. Moreover, Pearson r values increased to moderate to high levels Phase 1: 0.40 (Moderate), Phase 2: 0.79 (High), and Phase 3: 0.69 (High) showing better correlation in warm environment and during or after exercise. CV further decreased Phase 1: 0.70 (Low), Phase 2: 0.58 (Low), Phase 3: 0.53 (Low) showing even lower variability in measurements. LoA was found wide in both trials. Trial 1:0,38±0.50 (Wide), 0.45±0.69 (Wide),0.31±0.51(Wide), Trial 2: 0.29±0.51 (Wide), 0.20±0.42 (Wide), 0.13±0.39 (Wide),

4.3 Temporal Thermometer

In Trial 1, the device produced MD of +0.36°C during Phase 1, +0.83°C during Phase 2, and +0.84°C during Phase 3 indicating low accuracy by far exceeding (±0.3°C) cutoff. These large biases were accompanied by high effect size Phase 1: 1.06, Phase 2: 1.68, and Phase 3: 1.85 showing very significant statistical differences compared with gold standard. SD, Phase 1: ±0.48, Phase 2: ±0.63, Phase 3: ±0.57. MDSD was found big Phase 1: ±0.48, Phase 2: ±0.75, Phase 3: ±0.61. r was found very low (0.15) in Phase 1, negative and low in Phase 2 (-0.21), and very low again in Phase 3 (0.09) showing very low and even negative correlation, with wide LoA In Phases 1, 2 and 3 (±0.95°C, ±1.46°C, ±1.19°C respectively) and CV was moderate to high, Phase1: 1.59 (high), 1.51 (moderate) 1.53, (moderate).

In Trial 2, the discrepancies worsened, with MD increasing to +0.55°C in Phase 1, +0.76°C Phase 2, and +1.15°C Phase 3, no Phase manages to be within threshold of accuracy (±0.3°C). SD, Phase 1: ±0.56, Phase 2: ±0.44, Phase 3: ±0.48. Also effect size escalated further,1.38 for Phase 1, 2.01 for Phase 2 and 3.08 for Phase 3. MDSD were lower, Phase 1: ±0.58, Phase 2: ±0.48, Phase 3: ±0.48, or values ranged from very low to low 0.06 for Phase 1, 0.19 for Phase 2, and even negative -0. 21 for Phase 3. CV moderate to high Phase ±1:1.59, Phase 2: ±1.31, Phase 3: ±1.33 showing again high variability.

In both Trials Loa was wide, indicating further variability in measurements. Trial 1:0,36±0.9 (Wide), 0.83±1.46 (Wide), 0.84±1.19 (Wide) and Trial 2: 0.55±1.13 (Wide), 0.76±0.94 (Wide),1.15±0.95 (Wide)

4.4 Acoustic Membrane Thermometer

In Trial 1, the sensor dramatically underestimated temperature with very big MD Phase 1: +1.33°C, Phase 2: +1.30°C Phase 3: +1.33°C and big MDSD Phase 1: ±0.50 Phase 2: ±0.59 Phase 3: ±0.47. All MD values exceeded cutoff (±0.3°C), resulting in very large effect sizes Phase 1: 3.78, Phase 2: 2.76, Phase 3: 3.14 indicating very statistically significant differences with gold standard sensor. r values ranged from very low to moderate, Phase 1: 0.17 (Very low) Phase 2: 0.26 (Low) Phase 3: 0.42 (Moderate) indicating better correlation us internal temperature rises. CV values ranged Phase 1: 1.38 (Moderate), Phase 2: 1.63 (High), Phase 3: 1.31 (Moderate). SD, Phase 1: ±0.50, Phase 2: ±0.60, Phase 3: ±0.52.

Conversely. In Trial 2, the sensor's performance improved substantially, MD reduced, Phase 1: +0.10°C, Phase 2: +0.06°C, Phase 3: +0.07°C and MDSD lowered for every Phase, Phase 1: ±0.30, Phase 2: ±0.32, Phase 3: ±0.27. All MD

values did not exceed cutoff (±0.3°C), making it distinctively accurate. SD, Phase 1: ±0.33, Phase 2: ±0.37, Phase 3: ±0.35. Effect sizes were negligible to small Phase 1: 0.38 (Small) Phase 2: 0.18 (None) Phase 3: 0.24 (Small) and r values ranged from moderate to high Phase 1: 0.43 (Moderate), Phase 2: 0.57 (Moderate), Phase 3: 0.64 (High) reassuring the pattern of better correlation after rise of internal temperature.

In both Trials Loa was wide, indicating further variability in measurements. Trial 1: 1.33±0.98 (Wide), 1.30±1.16 (Wide), 1.33±0.93 (Wide) and Trial 2: 0.10±0.59 (Wide), 0.06±0.62 (Wide), 0.07±0.53 (Wide)

4.5 Calera sensor

The Calera Thermometer consistently overestimated temperature In Trial 1, MD for Phase 1: -0.46°C, Phase 2: -0.12°C, Phase 3: -0.42°C, with corresponding effect sizes of –1.39 (large), –0.33 (small), and –0.96 (large) and MDSD for Phase 1: ±0.48, Phase 2: ±0.55, Phase 3: ±0.61. Only Phase 2 MD is within the accuracy threshold (±0.3°C). SD, Phase 1: ±0.44, Phase 2: ±0.51, Phase 3: ±0.57. r showed very low and even negative correlation compared with gold standard, Phase 1: –0.08 (Very low), Phase 2: 0.17 (Very low), Phase 3: 0.08 (Very low). The CV for Phase 1: 1.30 (Moderate), Phase 2: 1.47 (Moderate), Phase 3: 1.64 (High) showed moderate to high variability in measurements.

In Trial 2, the sensor continued to overvalue temperature in every Phase. MD for Phase 1: -0.42°C, Phase 2: -0.10°C, and Phase 3: -0.40°C and relatively lower MDSD, Phase 1: ±0.37, Phase 2: ±0.44, Phase 3: 0.49. SD, Phase 1: ±0.33, Phase 2: ±0.39, Phase 3: ±0.41. Effect sizes ranged, Phase 1: –1.59 (Large), Phase 2: –0.29 (Small), Phase 3: –1.21 (Large). Again, only Phase 2 managed to not exceed the threshold of accuracy (±0.3°C). The r values Phase 1: 0.04 (Very low), Phase 2: 0.21 (Low), Phase 3: –0.06 (Very low and negative) showed weak and negative correlation with gold standard in this Trial. CV ranged from low to moderate, Phase 1: 1.00 (Low), Phase 2: 1.20 (Moderate), Phase 3: 1.32 (Moderate).

In both Trials LoA was found wide. Trial 1: 0.46±0.94 (Wide), 0.12±1.07 (Wide), 0.42±1.19 (Wide). Trial 2: 42±0.73 (Wide), 0.10±0.87 (Wide), 0.40±0.96 (Wide).

These graphs provide a visual representation of the correlation between sensors throughout all Phases of the protocol for Trial 1 and Trial 2 respectively

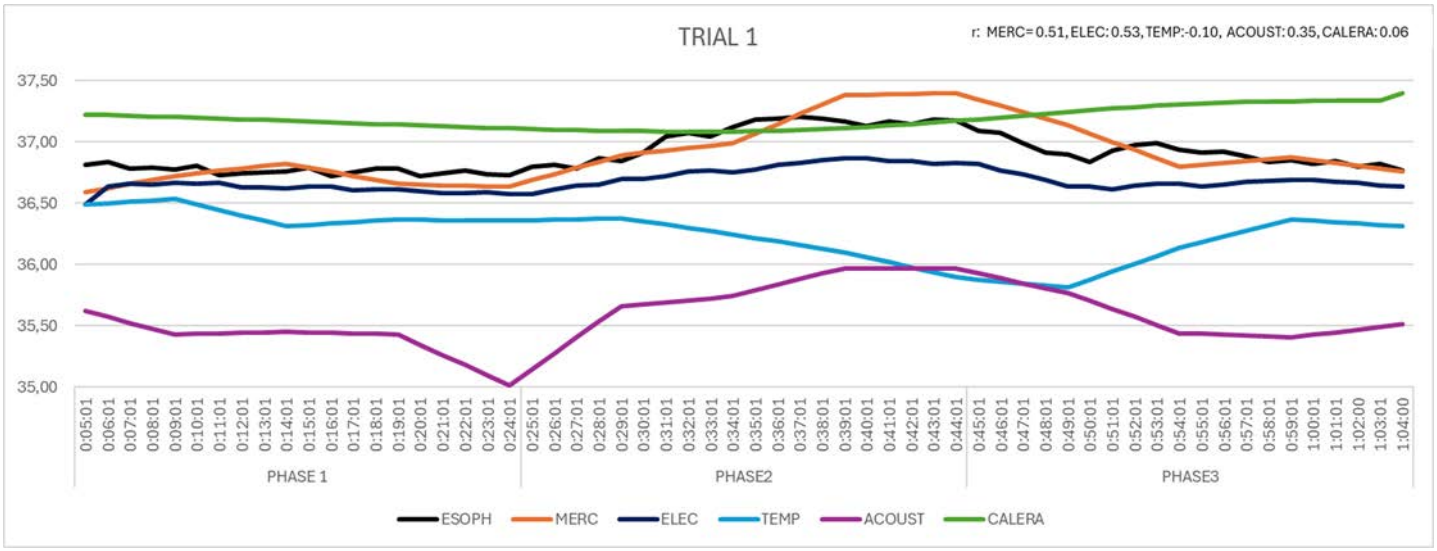


Table 6. Correlation of sensors Trial 1.

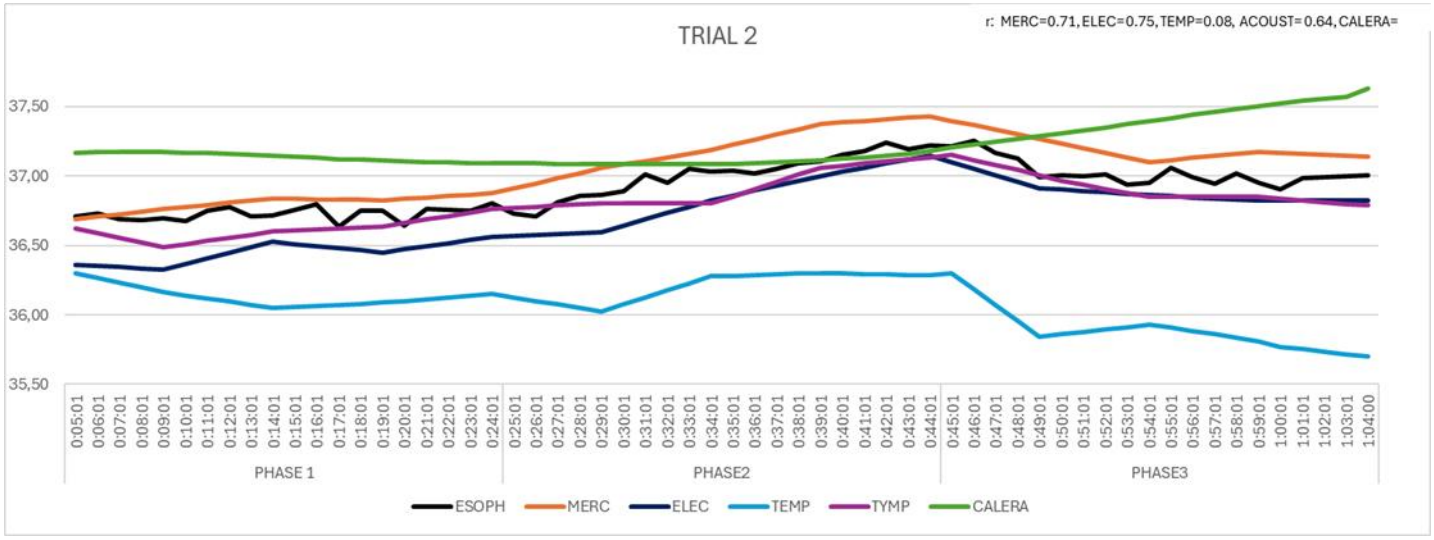


Table 7. Correlation of sensors Trial 2

These graphs provide a visual representation of the mean and SD values of sensors throughout all Phases of the protocol for Trial 1 and Trial 2 respectively.

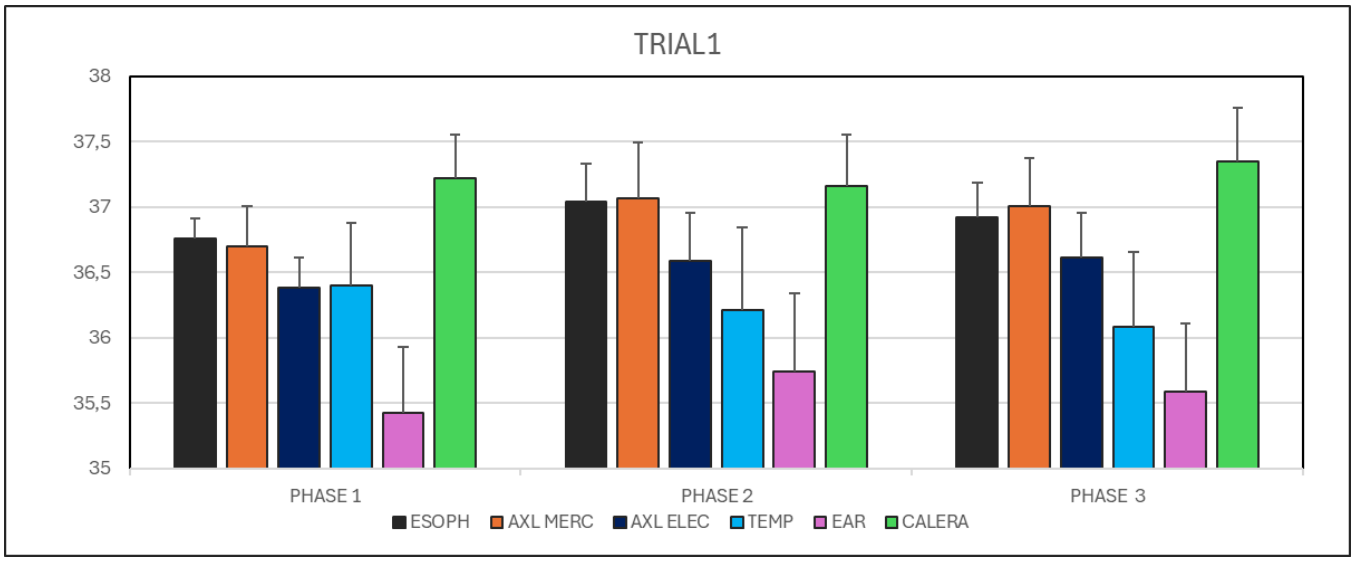


Table 8. Mean and SD all sensors Trial 1.

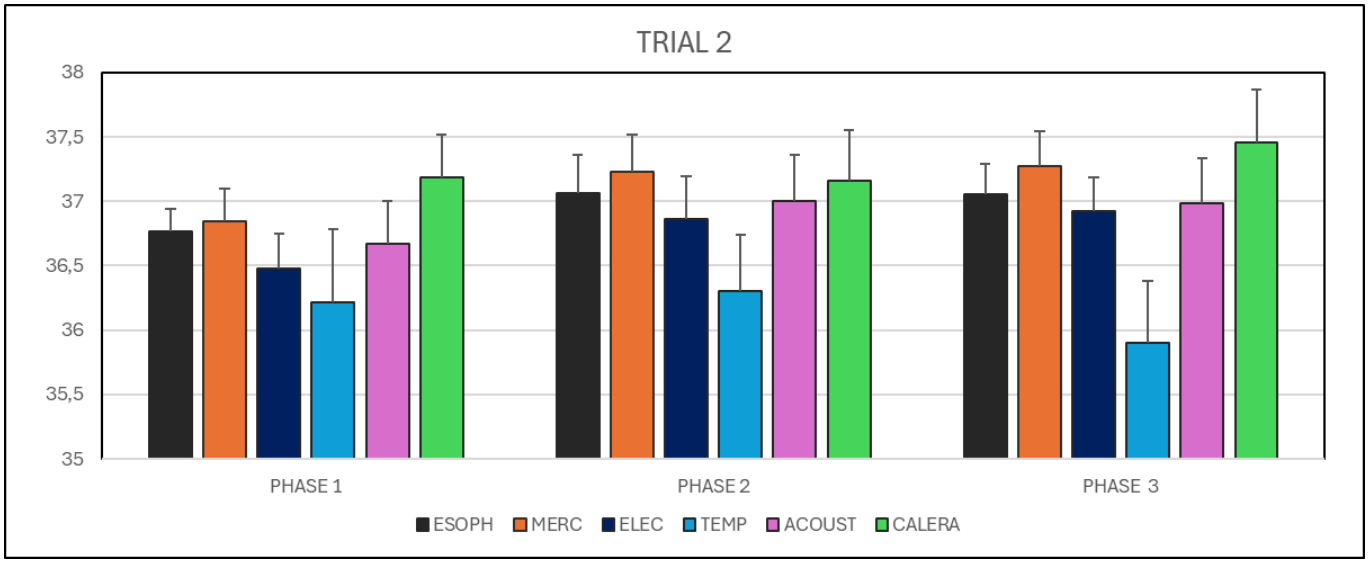


Table 9. Mean and SD all sensors Trial 2.

5 Discussion

The purpose of this study was to find the validity and reliability of non-invasive temperature sensors. To achieve that we compared the non-invasive sensors to the gold standard esophageal sensor in different physiological parameters (rest, exercise, recover) and different environmental conditions (neutral, 23-24°C and hot, 34-35°C, relative humidity 60%).

Our data indicates that the Mercury Axillary Thermometer provides the most valid and reliable temperature measurements across diverse environmental conditions and physiological states, exhibiting minimal bias, and overall good correlation r: 0.60. Also, coefficient of variation (CV) and standard deviation (SD), were small indicating good reliability. However, effect size d increased during exercise and recovery in heat and although Its measurements succeed in being accurate (±0.3°C) a slight impairment in correlation of the thermometer was observed in these specific conditions. It is important to inform, that LoA was found wide in both Trials. Indicating that despite good overall validity, variability is present, and individual measurements can vary from invasive reference. This shows that Mercury axillary indeed does not function as a replacement for esophageal sensor but as a reliable, non-invasive, easy to use alternative. Regarding the Mercury axillary thermometer there is no study comparing its validity and reliability in an exercise setting. But regarding its clinical application its notable precision is well known in the scientific community (16).

The Electronic Axillary Thermometer exhibited notable environmental and physiological dependence. With initial underestimation of Tc in a neutral environment that improves under warmer conditions. It also showed better correlation with gold standard during exercise and recovery phases in both trials. Its accuracy succeeds in being sufficient in hot environments (±0.3°C). The LoA was found wide in both Trials indicating a variability in measurements. Overall, the Electronic Axillary Thermometer is reliable with low CV and small SD. Its overall correlation with esophageal sensors was the best r: 0.64, showing a slight dip during rest and in neutral environment. The overall validity of the thermometer is not sufficient, but if specific parameters are met, in this case a warm environment and raised internal temperature, the electronic thermometer might be able to provide valid measurements. The electronic axillary thermometer has been tested for its validity and reliability by other studies during exercise in warm environment (15) and although the correlation was found moderate, the mean bias was high exceeding the cutoff rendering it invalid. In our study the axillary thermometer showed higher accuracy in hot environmental conditions. This difference could be the product of the difference in gold standard invasive sensor chosen, our study

used esophageal sensor which is regarded as more accurate in detecting Core body temperature in relation with rectal sensor (50, 73) that was used in the aforementioned studies. Rectal temperatures have proven to be higher than those in other parts of the body and it displays a considerable delay during rapid temperature changes (13). In contrast, the Temporal Thermometer exhibits substantial differences under all conditions, rendering it unsuitable for precise monitoring. With its overall accuracy being the lowest and having the weakest and even negative correlation with esophageal thermometer r: -0.02 (Very Weak) With high LoA. It also showed High CV and SD rendering it unreliable. The infrared temporal thermometer had the worst performance under both Trials therefore is invalid and unreliable and should not be used especially in scenarios where clinical importance is valuable. Concerning the temporal thermometer, other studies support our findings. Large discrepancies in accuracy have been detected, in a hot environment both at rest (15, 74) and during exercise. But in contrast to our findings, others(15) support that in thermoneutral conditions the temporal thermometer is valid. This could be attributed to the type of temporal thermometer they used in their study, which was a contact infrared thermometer whereas in our study we used a contactless infrared thermometer. Knowing that temperature measurements from contactless and contact temporal thermometers can differ (75) contributing to the difference between results. The Acoustic Membrane Thermometer's performance is highly dependent on external factors, achieving acceptable validity and reliability only under the elevated temperature of Trial 2, compared to neutral conditions. In Trial 1, the Acoustic Membrane sensor overestimated temperature by approximately +1.30°C with very large effect size. However, in Trial 2, its MD dropped to between +0.06°C and +0.10°C with negligible effect sizes and moderate-to-high Pearson r and variability decreased with low CV. Also, the correlation seems to be better in the phases of exercise and recovery compared to rest indicating stronger correlation with rise of internal and environmental temperature. Overall, the sensor shows low correlation with gold standard r: 0.35 (Weak) it shows low reliability with big SD and high CV and bad validity with large discrepancies in MD, MDSD and Wide LoA. But similarly to axillary thermometer it seems that in high environmental heat and during exercise the Acoustic membrane thermometer Might be useful in temperature measuring. According to other studies(55), when measuring acoustic membrane temperatures the readings can be accurate for Tc measurement when the device is in direct contact with the acoustic membrane. For that to be possible, it needs a well-trained individual and a modified thermocouple, probe the accuracy drops when using an infrared tympanic membrane thermometer. Similarly to our study the low accuracy of tympanic membrane thermometer during resting in thermoneutral conditions has been previously recorded (47, 56, 70) and although high corelation with invasive

sensors was previously reported (7) our results identified high accuracy present when used in a hot environment during exercise, rest and recovery. This could be a matter of multiple reasons such us airflow (59), degree of hyperthermia (70), difference between device calibration and the differences in accuracy of invasive sensors. More specifically, in our study the esophageal sensor was used as gold standard whereas in the aforementioned studies(47, 56, 70) a rectal sensor was used. Comparatively the esophageal sensor is considered more accurate (13, 50, 51, 73). The Calera sensor, which generally overestimates temperature, appears to perform relatively better during exercise (Phase 2) compared to resting or recovery phases. In both trials, the Calera sensor showed MD around –0.12°C (Trial 1) and –0.10°C (Trial 2) during exercise, values that are considerably lower than the underestimations observed during resting and recovery. This improvement may be attributed to the physiological changes during exercise, such as increased peripheral blood flow and vasodilation, which minimizes the thermal gradient between the body's core and peripheral sites. As a result, the Calera sensor's inherent overestimation is mitigated during exercise, leading to readings that are closer to the esophageal measurements. This might be due to the calibration of the sensor due to its specialization to a sports performance driven audience. Although Calera seems to display better precision during exercise, the weak and even negative correlation compared with gold standard sensor renders it unfit for overall temperature monitoring. These findings underscore the importance of considering both environmental conditions and physiological state when selecting and calibrating temperature sensors for clinical, common and sports specific usage. Lastly, regarding the Clera sensor other studies have also recorded low accuracy in temperature measurements, (17, 67, 76, 77). Only one of them recorded the overestimation of Tc by The Calera sensor and only in neutral environment (76) same study and others showed significant underestimation of Tc by Calera sensor (66, 77). Furthermore, two studies found the Calera sensor valid for estimating Tc during exercise(67, 78). These differences in results could be attributed to the exercise protocol difference. In our study we used lower intensity than the studies also the length of our protocol was also shorter. Another contributing factor could be the difference in gold standard sensors, in other studies gastrointestinal temperature measured by telemetric pill was used whereas in this study we used esophageal temperature. Differences between Esophageal and gastrointestinal temperature in neutral and hot conditions during exercise have been recorded, with the latter showing consistently higher Tc readings (52).It is also important to note that esophageal temperature is considered highly accurate do to its comparable performance in Tc measurement with pulmonary artery Swan-Ganz catheter.(13, 51)

6 Limitations and Future proposals

In this study the time of exercise was relatively short (20 minutes) and the intensity of the exercise protocol was low 60% of the maximum heart rate, adjusted for age according to the Karvonen equation (Target Heart Rate = [(max HR − resting HR) × %Intensity] + resting HR) (1). Also, we did not re-introduce exercise after recovery to see how the sensors would react to fluctuations in temperature. Subsequently to extend further scientific testing for temperature measuring sensors in the future, a prolonged experimental protocol could be used, with a more intense exercise phase and the addition of post recovery exercise to see the reaction of the sensors.

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7 Appendix

The International Physical Activity Questionnaire (IPAQ was used in Greek translation)

Σύντομο Διεθνές Ερωτηματολόγιο Φυσικής Δραστηριότητας

Μία συνηθισμένη εβδομάδα

Οι παρακάτω ερωτήσεις αφορούν το χρόνο που έχετε αφιερώσει για κάποια σωματική δραστηριότητα **κατά τη διάρκεια μιας συνηθισμένης εβδομάδας**. Περιλαμβάνουν ερωτήσεις σχετικά με δραστηριότητες που κάνατε κατά την εργασία σας, στις μετακινήσεις σας, στις δουλειές του σπιτιού, του κήπου και στον ελεύθερο χρόνο σας για ψυχαγωγία, άσκηση ή άθληση. Σας παρακαλώ να απαντήσετε όλες τις ερωτήσεις, ακόμα και εάν πιστεύετε ότι δεν είστε ένα σωματικά δραστήριο άτομο.

Πριν απαντήσετε τις ερωτήσεις 1 και 2, σκεφτείτε όλες τις **έντονες** σωματικές δραστηριότητες που κάνατε **κατά τη διάρκεια μιας συνηθισμένης εβδομάδας.** Μια έντονη σωματική δραστηριότητα αναφέρεται σε δραστηριότητες που απαιτούν έντονη σωματική προσπάθεια και σας κάνουν να αναπνέετε σημαντικά δυσκολότερα από ότι συνήθως. Σκεφθείτε μόνο τις **έντονες** σωματικές δραστηριότητες που κάνατε και είχαν διάρκεια **μεγαλύτερη από 10 λεπτά** κάθε φορά.

1. **Κατά τη διάρκεια μιας συνηθισμένης εβδομάδας, πόσες ημέρες κάνατε κάποια μέτρια σωματική δραστηριότητα, όπως το να σηκώσετε και να μεταφέρετε ελαφρά βάρη (μικρότερα από 10 κιλά), συνολική καθαριότητα του σπιτιού, ήπιες ρυθμικές ασκήσεις σώματος, ποδηλασία αναψυχής με χαμηλή ταχύτητα, χαλαρή κολύμβηση; Σας παρακαλώ να μη συμπεριλάβετε το περπάτημα**.

   ..... ημέρες ανά εβδομάδα
   αν δεν κάνατε μέτριας έντασης σωματικές δραστηριότητες, σημειώστε Χ

   εδώ ☐ και προχωρήστε στην ερώτηση 5.

2. **Τις ημέρες που κάνατε κάποια μέτρια σωματική δραστηριότητα πόση ώρα αφιερώνατε συνήθως;**

   ..... λεπτά ανά ημέρα δεν γνωρίζω/δεν είμαι βέβαιος ☐

Πριν απαντήσετε στις ερωτήσεις 5 και 6, σκεφτείτε το χρόνο που περπατήσατε **κατά τη διάρκεια μιας συνηθισμένης εβδομάδας.** Να συμπεριλάβετε το περπάτημα στο χώρο της εργασίας σας, στις μετακινήσεις σας και στον ελεύθερο χρόνο σας για ψυχαγωγία, άσκηση ή άθληση.

3. **Κατά τη διάρκεια μιας συνηθισμένης εβδομάδας, πόσες ημέρες περπατήσατε για περισσότερο από 10 συνεχόμενα λεπτά;**
   ..... ημέρες ανά εβδομάδα

   αν δεν περπατήσατε καμία ημέρα περισσότερο από 10 συνεχόμενα

   λεπτά, σημειώστε Χ εδώ ☐ και προχωρήστε στην ερώτηση 7.

4. **Τις ημέρες που περπατήσατε, για περισσότερο από 10 συνεχόμενα λεπτά, πόση ώρα περάσατε περπατώντας;**

   ..... λεπτά ανά ημέρα δεν γνωρίζω/δεν είμαι βέβαιος ☐

5. **Πόσο χρόνο περάσατε καθισμένοι σε μία συνηθισμένη μέρα κατά τη διάρκεια μιας συνηθισμένης εβδομάδας; Ο χρόνος αυτός μπορεί να περιλαμβάνει το χρόνο που περνάτε καθισμένοι στο σπίτι, στο γραφείο, όταν επισκέπτεστε φίλους, όταν διαβάζετε, μελετάτε ή βλέπετε τηλεόραση, αλλά δεν περιλαμβάνει τον ύπνο.**

   ..... ώρες ανά ημέρα δεν γνωρίζω/δεν είμαι βέβαιος ☐

Τέλος ερωτηματολογίου. Σας ευχαριστούμε για τη συμμετοχή σας

Εργαστήριο Περιβαλλοντικής Φυσιολογίας FAME Lab
Φόρμα Ιατρικού Ιστορικού

Όνομα: _____ Ημερ.: __/ __/ ____ Ημερ. __/ __/ ____
Γέννησης:
HH MM XXXX HH MM XXXX

ΠΑΡΟΥΣΑ ΚΑΤΑΣΤΑΣΗ

1. Από όσο γνωρίζετε, είστε σε καλή υγεία την παρούσα περίοδο; Ναι ☐ Όχι ☐
Αν απαντήσατε "Όχι", παρακαλώ εξηγήστε τους λόγους:

_____
_____
_____
_____
_____
_____

2. Είστε υπό τη φροντίδα γιατρού την παρούσα περίοδο; Ναι ☐ Όχι ☐
Αν απαντήσατε "Ναι", παρακαλώ εξηγήστε τους λόγους:

_____
_____
_____
_____
_____
_____

3. Λαμβάνετε κάποια συνταγογραφούμενη φαρμακευτική αγωγή την παρούσα περίοδο;
Ναι ☐ Όχι ☐
Αν απαντήσατε "Ναι", παρακαλώ αναφέρετε λεπτομέρειες:

Συνταγογραφούμενη αγωγή:	Δοσολογία:
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

4. Λαμβάνετε κάποια μη συνταγογραφούμενη φαρμακευτική αγωγή την παρούσα περίοδο;
Ναι ☐ Όχι ☐
Αν απαντήσατε "Ναι", παρακαλώ αναφέρετε λεπτομέρειες:

Μη συνταγογραφούμενη αγωγή:	Δοσολογία:
_____	_____
_____	_____
_____	_____

_____ _____
_____ _____
_____ _____
_____ _____

5.Έχετε ιστορικό υψηλής αρτηριακής πίεσης; Ναι ☐ Όχι ☐
6. Έχετε ιστορικό διαβήτη; Ναι ☐ Όχι ☐
7. Έχετε ιστορικό καρδιακού εμφράγματος, θωρακικού πόνου,
ή άλλων καρδιακών παθήσεων; Ναι ☐ Όχι ☐
8. Έχετε ιστορικό πρηξίματος των ποδιών; Ναι ☐ Όχι ☐
9. Έχετε ιστορικό αγγειακής νόσου; Ναι ☐ Όχι ☐
10.Έχετε ιστορικό συχνών πονοκεφάλων; Ναι ☐ Όχι ☐
11.Έχετε ιστορικό συχνών ημικρανιών; Ναι ☐ Όχι ☐
12.Έχετε ιστορικό δυσκοιλιότητας; Ναι ☐ Όχι ☐
13.Έχετε ιστορικό γλαυκώματος; Ναι ☐ Όχι ☐
14.Έχετε ιστορικό υπνικής άπνοιας; Ναι ☐ Όχι ☐
15 Έχετε ιστορικό δυσλιπιδαιμίας; Ναι ☐ Όχι ☐
16 Έχετε ιστορικό υψηλών τριγλυκεριδίων; Ναι ☐ Όχι ☐
17.Έχετε ιστορικό υψηλής γλυκόζης; Ναι ☐ Όχι ☐
18.Έχετε ιστορικό μεταβολικού συνδρόμου; Ναι ☐ Όχι ☐
19 Έχετε ιστορικό νεφρικής ανεπάρκειας; Ναι ☐ Όχι ☐
20. Έχετε ιστορικό πόνου/αδυναμίας των αρθρώσεων; Ναι ☐ Όχι ☐
21. Έχετε ιστορικό πόνου/αδυναμίας των μυών; Ναι ☐ Όχι ☐
22. Έχετε ιστορικό ασθένειας του θυρεοειδούς; Ναι ☐ Όχι ☐
23. Έχετε ιστορικό ανοσολογικών ασθενειών; Ναι ☐ Όχι ☐
24. Έχετε ιστορικό καρκίνου; Ναι ☐ Όχι ☐
25. Έχετε ιστορικό κατάχρησης αλκοόλ; Ναι ☐ Όχι ☐
26. Έχετε ιστορικό χρήσης ναρκωτικών ουσιών; Ναι ☐ Όχι ☐
27. Έχετε ιστορικό αιμορροφιλίας; Ναι ☐ Όχι ☐
28. Έχετε ιστορικό ηπατίτιδας; Ναι ☐ Όχι ☐
29. Έχετε ιστορικό υπερθερμίας; Ναι ☐ Όχι ☐
30. Έχετε ιστορικό καπνίσματος; Ναι ☐ Όχι ☐

Αν απαντήσατε ''Ναι'' αναφέρετε πόσα πακέτα καπνίζετε ή καπνίζατε ημερησίως:
_____

Αν απαντήσατε ''Ναι'' αναφέρετε πόσα χρόνια καπνίζετε ή καπνίζατε: _____

31. Καπνίζετε την παρούσα περίοδο; Ναι ☐ Όχι ☐

32. Χρησιμοποιείτε οποιαδήποτε άλλη μορφή καπνού; Ναι ☐ Όχι ☐

Αν απαντήσατε ''Ναι'', παρακαλώ εξηγήστε:

_____
_____
_____
_____
_____

33. Έχετε ιστορικό σοβαρών τραυματισμών; Ναι ☐ Όχι ☐

Αν απαντήσατε ''Ναι'', παρακαλώ αναφέρετε λεπτομέρειες και ημερομηνίες:

_____
_____
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_____

34. Έχετε ιστορικό χειρουργικών επεμβάσεων; Ναι ☐ Όχι ☐

Αν απαντήσατε ''Ναι'', παρακαλώ αναφέρετε λεπτομέρειες και ημερομηνίες:

_____
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_____

ΠΛΗΡΟΦΟΡΙΕΣ ΣΩΜΑΤΙΚΟΥ ΒΑΡΟΥΣ:

35. Ποιο είναι το επιθυμητό σας βάρος; _____ (kg)

36. Ποιο είναι το μέγιστο βάρος που έχετε φτάσει (όχι σε κατάσταση εγκυμοσύνης); _____ (kg)

37. Ποιο ήταν το βάρος σας πριν 1 χρόνο; _____ (kg)

38. Ποιο ήταν το βάρος σας στην ηλικία των 20 ετών; _____ (kg)

39. Ποιο ήταν το βάρος σας κατά τη γέννηση σας; _____ (kg)

ΠΛΗΡΟΦΟΡΙΕΣ ΒΡΕΦΙΚΗΣ ΗΛΙΚΙΑΣ:

40. Που έχετε γεννηθεί; _____ (Χωριό/Πόλη) _____ (Νομός) _____ (Χώρα)

41. Πόσο χρονών ήταν η μητέρα σας όταν γεννηθήκατε; _____

42. Πόσο χρονών ήταν ο πατέρας σας όταν γεννηθήκατε? _____

43. Για πόσους μήνες θηλάζετε; _____

ΙΣΤΟΡΙΚΟ ΟΙΚΟΓΕΝΕΙΑΣ

	Ηλικία	Ασθένειες	Αν έχουν αποβιώσει, δηλώστε αιτία θανάτου	
Πατέρας				Υπέρβαροι; Ναι ☐ Όχι ☐
Μητέρα				Υπέρβαροι; Ναι ☐ Όχι ☐
Αδελφοί				Υπέρβαροι; Ναι ☐ Όχι ☐
Αδελφές				Υπέρβαροι; Ναι ☐ Όχι ☐
				Υπέρβαροι; Ναι ☐ Όχι ☐
				Υπέρβαροι; Ναι ☐ Όχι ☐

ΤΜΗΜΑ ΕΠΙΣΤΗΜΗΣ ΦΥΣΙΚΗΣ ΑΓΩΓΗΣ ΚΑΙ ΑΘΛΗΤΙΣΜΟΥ.
ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΙΑΣ
ΚΑΡΥΕΣ
ΤΡΙΚΑΛΑ 42100

Ονοματεπώνυμο:

Ημερομηνία:

I.D.:

Ημερομηνία γέννησης:

(Σημειώστε Χ αν ισχύει)

Ιστορικό **ΗΜΕΡΟΜΗΝΊΑ**
(Είχατε ποτέ;)

Διαβήτη τύπου 1	( )
Διαβήτη τύπου 2	( )
Ρευματικό πυρετό	( )
Φύσημα στην καρδιά	( )
Υψηλή αρτηριακή πίεση	( )
Κάποιο καρδιακό πρόβλημα	( )
Αρτηριακή ασθένεια	( )
Φλεβικούς κιρσούς	( )
Πνευμονική ασθένεια	( )
Εγχειρήσεις	( )
Τραυματισμούς στη μέση, στα γόνατα, στην ποδοκνημική	( )
Επιληψία	( )
Ο,τιδήποτε άλλο	( )

Εξηγήστε:_____

Ιστορικό οικογενείας **Ηλικία** **Συγγένεια**
(Είχε κάποιος από τους συγγενείς σας;)

Καρδιακή προσβολή	( )
Υψηλή αρτηριακή πίεση	( )
Υψηλά επίπεδα χοληστερίνης	( )
Διαβήτη	( )
Συγγενή καρδιοπάθεια	( )
Εγχειρήσεις καρδιάς	( )
Ο,τιδήποτε άλλο	( )

Εξηγήστε:_____

Φάρμακα:_____

ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΙΑΣ
ΤΜΗΜΑ ΕΠΙΣΤΗΜΗΣ ΦΥΣΙΚΗΣ ΑΓΩΓΗΣ ΚΑΙ ΑΘΛΗΤΙΣΜΟΥ

Εσωτερική Επιτροπή Δεοντολογίας

Τρίκαλα: 3.4.2024
Αριθμ. Πρωτ.: 2373

Βεβαίωση έγκρισης της πρότασης για διεξαγωγή έρευνας με τίτλο: Εγκυρότητα μη παρεμβατικών μετρήσεων θερμοκρασίας σώματος σε σχέση με τη θερμοκρασία οισοφάγου σε ηρεμία, άσκηση και την αποκατάσταση σε θερμό και ουδέτερο περιβάλλον

Επιστημονικώς υπεύθυνος-η / επιβλέπων-ουσα: Φλουρής Ανδρέας
Ιδιότητα: Αναπληρωτής Καθηγητής
Ίδρυμα: Πανεπιστήμιο Θεσσαλίας
Τμήμα: ΤΕΦΑΑ

Κύριος ερευνητής-τρια / φοιτητής-τρια: Ροδίτης Οδυσσέας
Πρόγραμμα Σπουδών: Προπτυχιακό
Ίδρυμα: Πανεπιστήμιο Θεσσαλίας
Τμήμα: ΤΕΦΑΑ

Η προτεινόμενη έρευνα θα είναι: Πτυχιακή εργασία

Τηλ. επικοινωνίας:
Email επικοινωνίας: Αφαίρεση προσωπικών δεδομένων (Υπηρεσία Βιβλιοθήκης & Πληροφόρησης Πανεπιστημίου Θεσσαλίας)

Η Εσωτερική Επιτροπή Δεοντολογίας του Τ.Ε.Φ.Α.Α., Πανεπιστημίου Θεσσαλίας μετά την υπ. Αριθμ. 1-8/3.4.2024 συνεδρίασή της εγκρίνει τη διεξαγωγή της προτεινόμενης έρευνας.

Ο Πρόεδρος της
Εσωτερικής Επιτροπής Δεοντολογίας
– ΤΕΦΑΑ

Τσιόκανος Αθανάσιος
Καθηγητής