# The need of human body composition measurement in Dietetics

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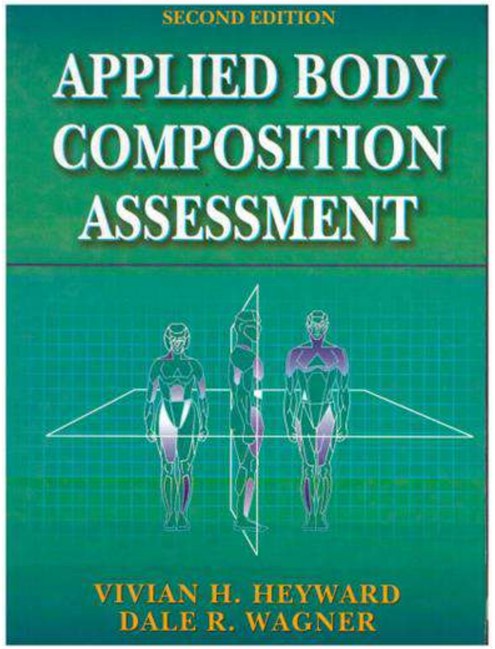
# CORRECT DEFINITION OF OBESITY




- Most of the health professionals use the ***Body Mass Index, BMI*** (body mass to height square) in order to categorize a subject into one of the following categories: ***underweight, normal, overweight, obesity I, obesity II*** and ***obesity III***
- In pages 4-5 of the Book "Applied body composition assessment" it is stated: *"The BMI does not take into account the composition of the individual's body weight. For example, individuals with a high BMI value may have either excess fat or a large lean body mass.* ***Obesity, therefore, may be better defined as an excessive amount of body fat relative to body weight*** *..."*

# AN EXAMPLE OF THE *BMI* FAILURE

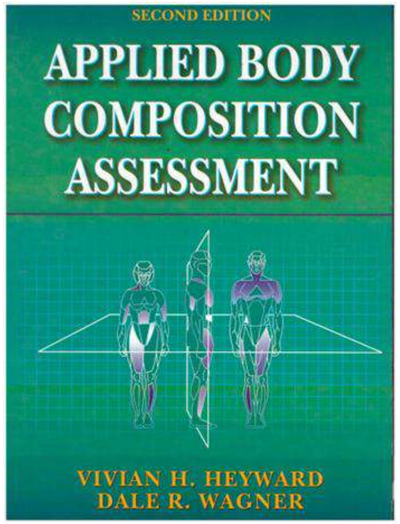
- Both subjects have the same *BMI* ! *BMI* = 31 kg/m$^2$. Are they both obese?
- If we measure the percent body fat *(%BF*) we will find

  On the left: *%BF* = 32%

  On the right: *%BF* = 11%
- How will it look like if a dietician or even a physician advises the man standing to the right to lose weight? !!!

# THE CORRECT DEFINITION OF OBESITY – ACCEPTABLE LIMITS OF %BF

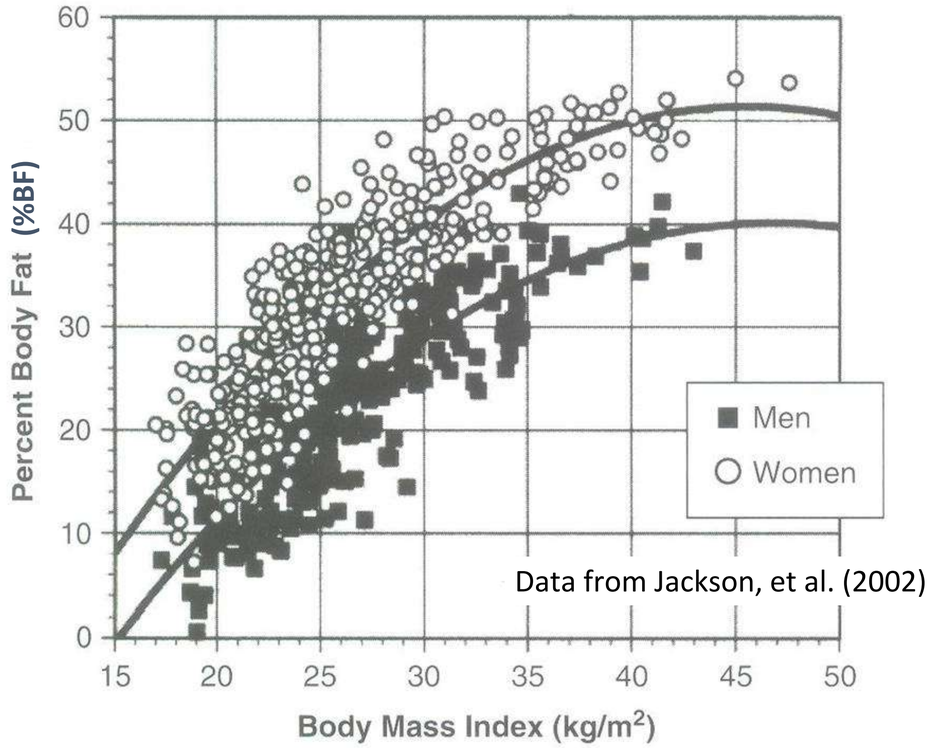
| | | Not recommended | Low Limit | Normal / Mean | High Limit | Overweight Limit | Obesity Limit |
|---|---|---|---|---|---|---|---|
| **MEN** 6-17 years | | < 5 | 5-10 | 10-25 | 25 | > 25 | > 31 |
| 18-34 years | | < 8 | 8 | 13 | 22 | > 22 | > 28 |
| 35-55 years | | < 10 | 10 | 18 | 25 | > 25 | > 28 |
| 55+ years | | < 10 | 10 | 16 | 23 | > 23 | > 28 |
| **WOMEN** 6-17 years | | < 12 | 12-15 | 16-30 | 30 | > 30 | > 36 |
| 18-35 years | | < 20 | 20 | 28 | 35 | > 35 | > 41 |
| 34-55 years | | < 25 | 25 | 32 | 38 | > 38 | > 41 |
| 55+ years | | < 25 | 25 | 30 | 35 | > 35 | > 41 |
| | *References* | | | *A* | | | *B* |

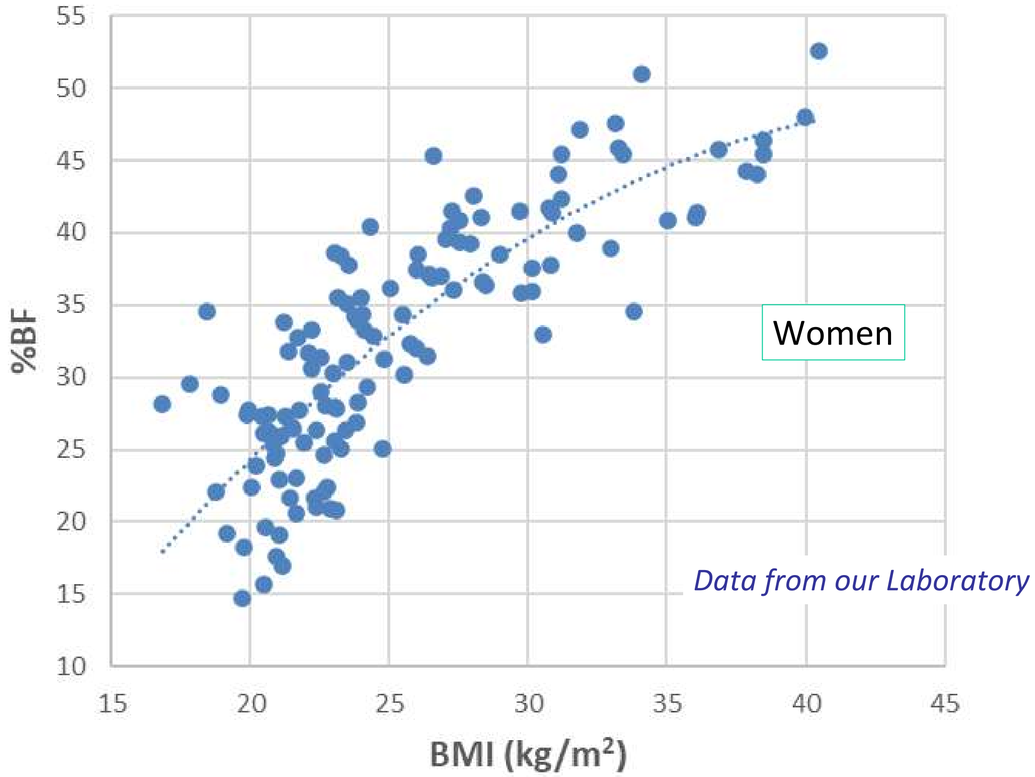



***Reference A***
**page 6**


***Reference B***
**page 17**

# WHY THE *BMI* FAILS?

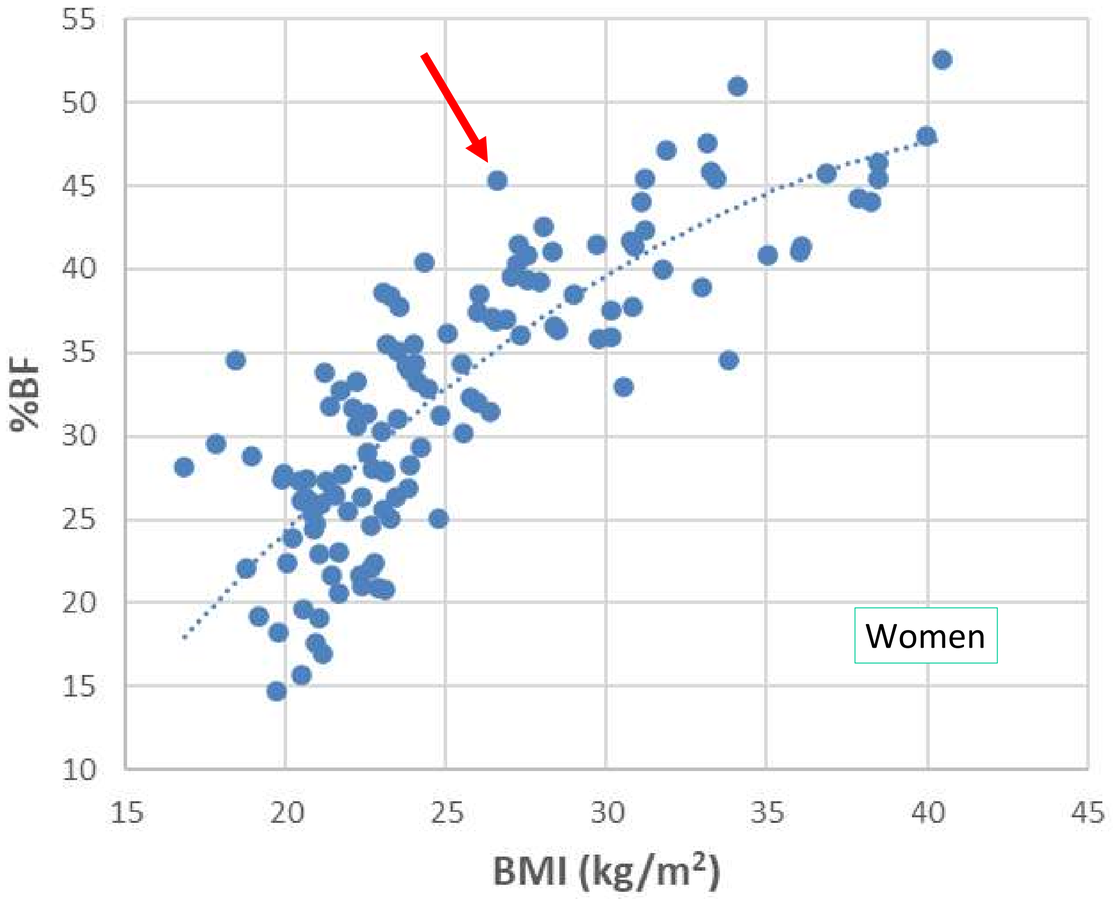



A) The *BMI* provides a correct assessment of the obesity status only for the points (subjects) that lye on or nearby the least-squares curve. All the other points require a different obesity status interpretation.

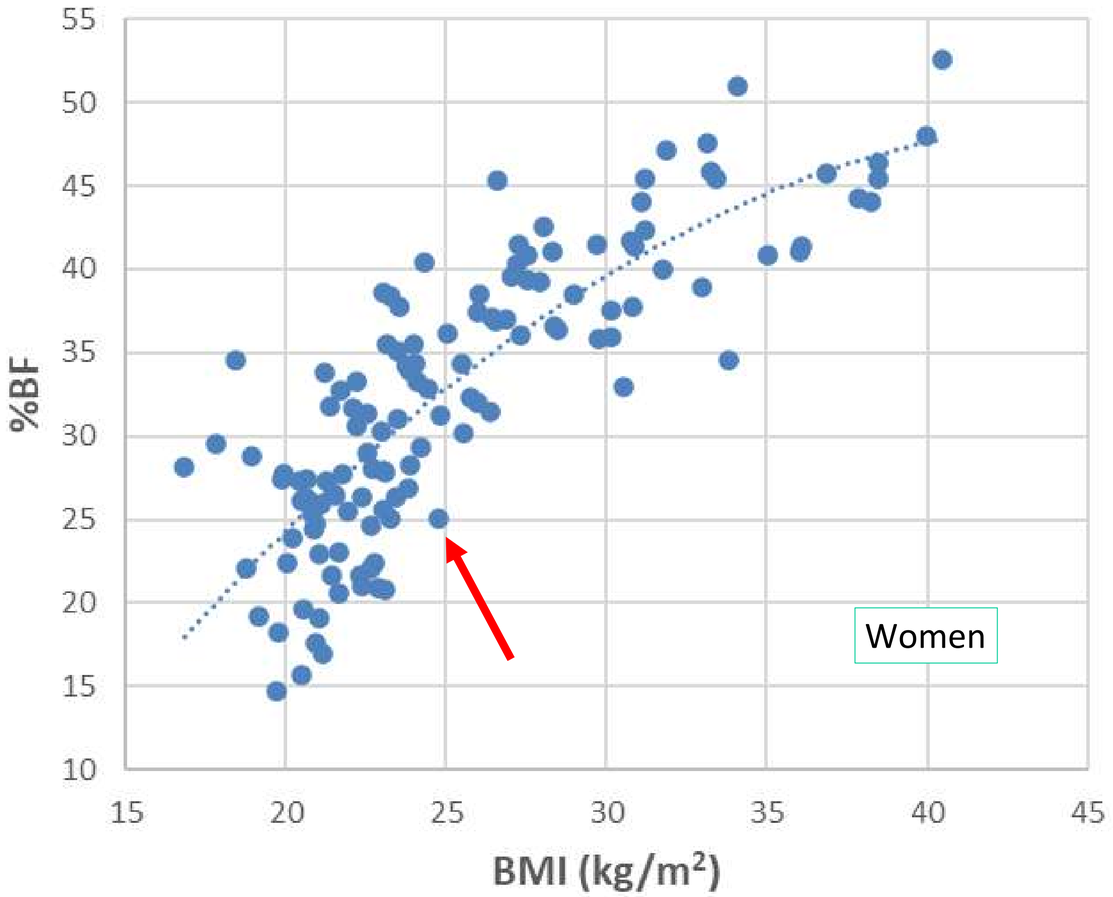
B) The combined data of *%BF* and *BMI* provides additional assessment of the muscular mass !

# WHEN *BMI* UNDERESTIMATES OBESITY STATUS




- For example, consider the designated point. It corresponds to a woman (age 51 years) of *BMI* = 26.6 kg/m$^2$ and *%BF* = 45.3%.
- The *BMI* indicates an overweight woman but, according to *%BF*, she is obese! So, apparently, she has a decreased muscular mass.

# WHEN *BMI* OVERESTIMATES OBESITY STATUS




- For example, consider the designated point. It corresponds to a woman (age 26 years) of *BMI* = 24.7 kg/m$^2$ and *%BF* = 25%.
- The *BMI* indicates a woman very close become overweight but, according to *%BF*, not only she is normal, but she is below the average *%BF*. So, apparently, she has an increased muscular mass.

# UNCOVERING SARCOPENIC OBESITY

- The combination of reduced muscle mass with simultaneously increased caloric intake and reduced physical activity creates the phenomenon of sarcopenic obesity or, in simple words, the “hidden” obesity that we find in some “thin” individuals, after measuring their body composition.
- While the weight of these persons is “normal”, we find an increased percentage of adipose tissue and reduced muscle mass. As a result, they are actually “overweight” or “obese” and not “normal” as the *BMI* indicates.
- Usually this phenomenon is observed in women who are in menopause and while some of them may look normal/thin, the percentage of fat tissue in their body is excessively high.
- Reduced muscle mass leads to a reduced basal metabolism, as a result of which these women tend to "gain" weight more easily.

# HOW OFTEN THE *BMI* FAILS?

- Our up-to-now data on 233 subjects (men and women) of ages between 18 and 83 years old shows a *BMI* failure of 38%.
- Our cohort consists of volunteers; therefore, a randomly chosen sample of all lifestyles, backgrounds and ages may result in a higher than 38% failure. Our estimation points to a number higher than 40%.
- On the other hand, if we restrict to a cohort of median lifestyle the percentage may drop below 38%.
- In any case, the systematic measurement of percent body fat is of crucial importance for the exact assessment of the obesity status.

# OBESITY IN CHILDREN

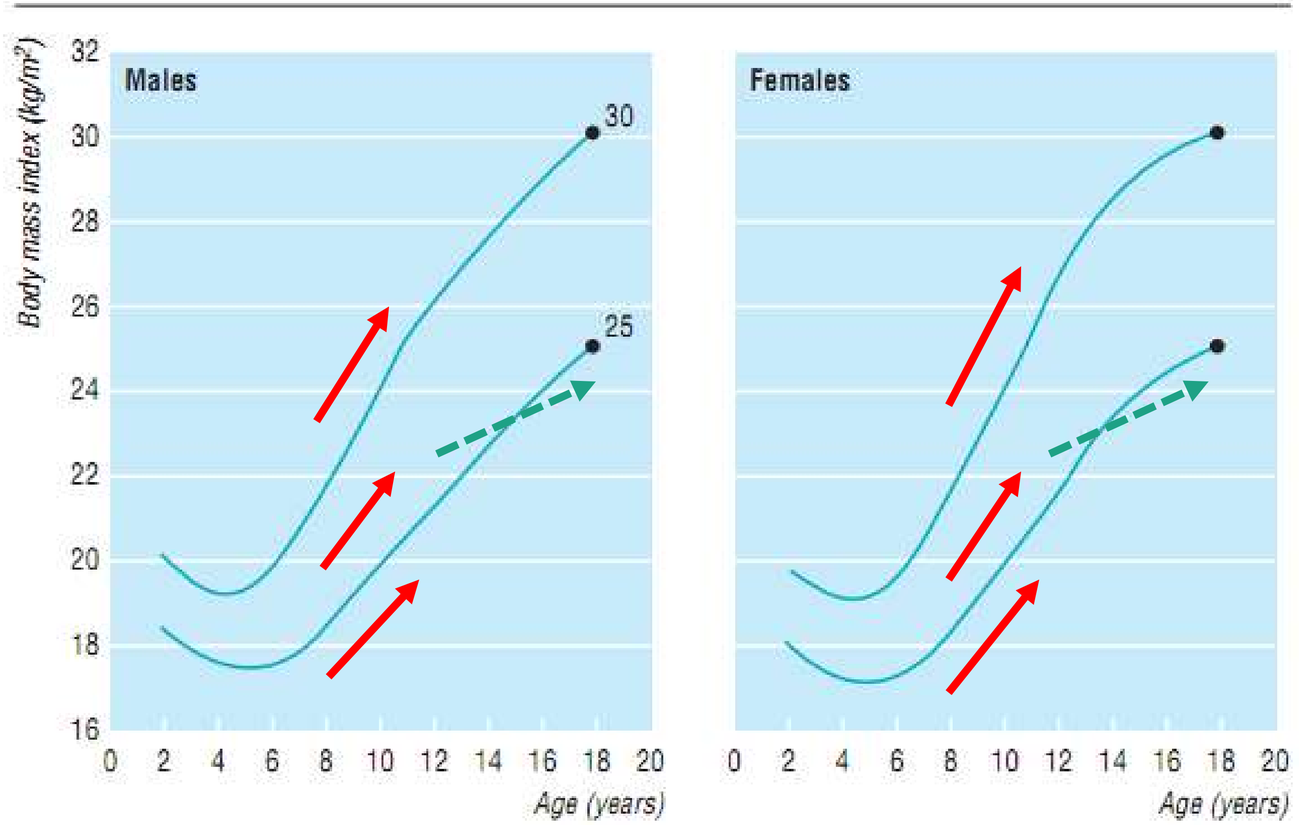



**Fig 6** International cut off points for body mass index by sex for overweight and obesity, passing through body mass index 25 and 30 kg/m² at age 18 (data from Brazil, Britain, Hong Kong, Netherlands, Singapore, and United States)

**Question:**

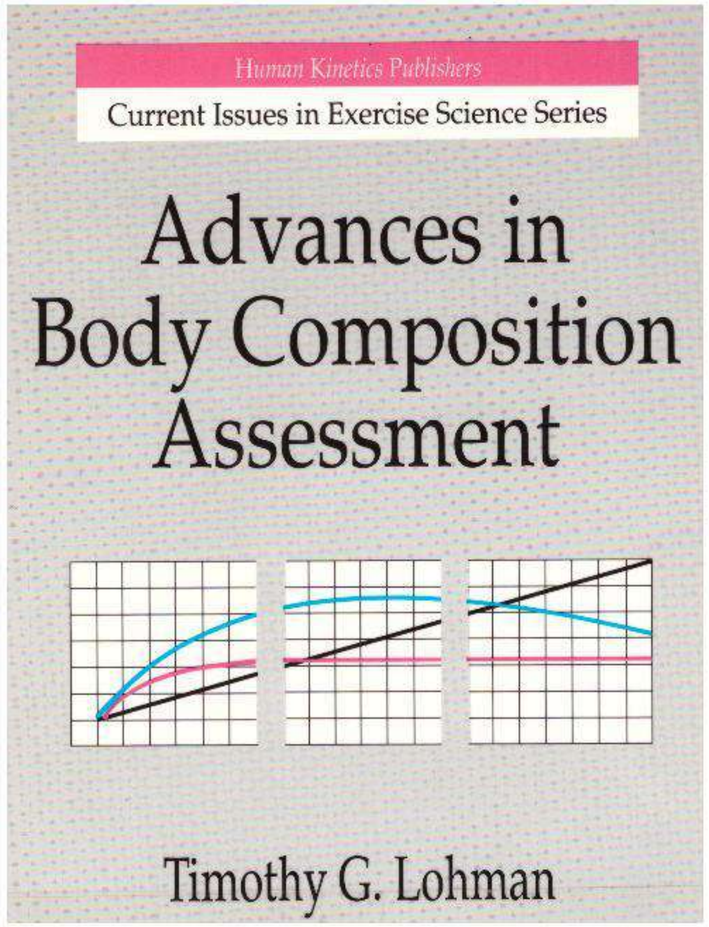
***Since the BMI in children increases with age, how is it possible to measure the result of an intervention in a Longitudinal Study?***

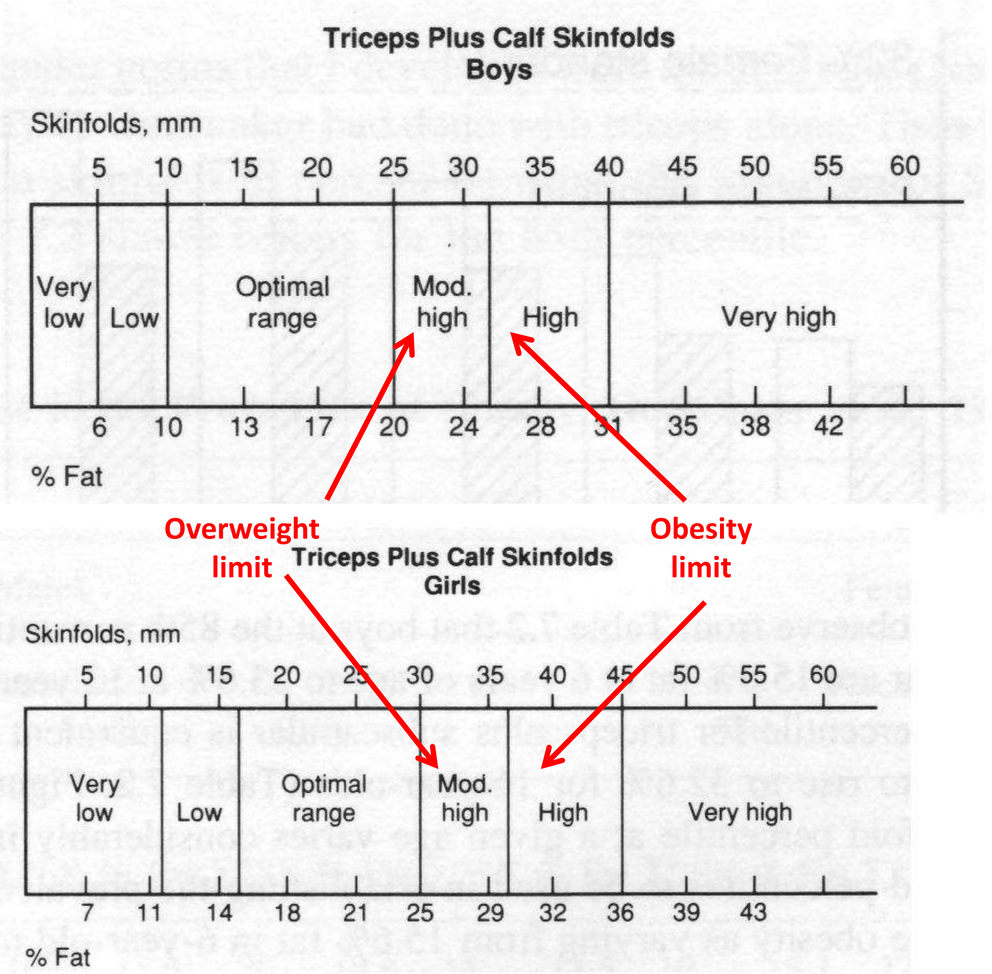
**Answer:**

***A successful intervention results in a decrease of %BF; therefore we must measure %BF before and after the intervention.***

*'s taken from T.J. Cole et al., BMJ VOLUME 320, 6 MAY 2000*

# *%BF* RANGES IN CHILDREN



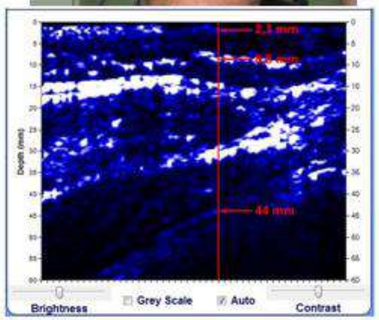
# METHODS USED IN OUR LAB

UNDERWATER WEIGHING


PLETHYSMOGRAPHY / BODPOD

DEXA

BIOELECTRICAL IMPEDANCE SPECTROSCOPY (BIS)




ULTRASOUND

NIR

INDIRECT CALORIMETRY
&
PULMONARY VOLUMES

SKINFOLDS

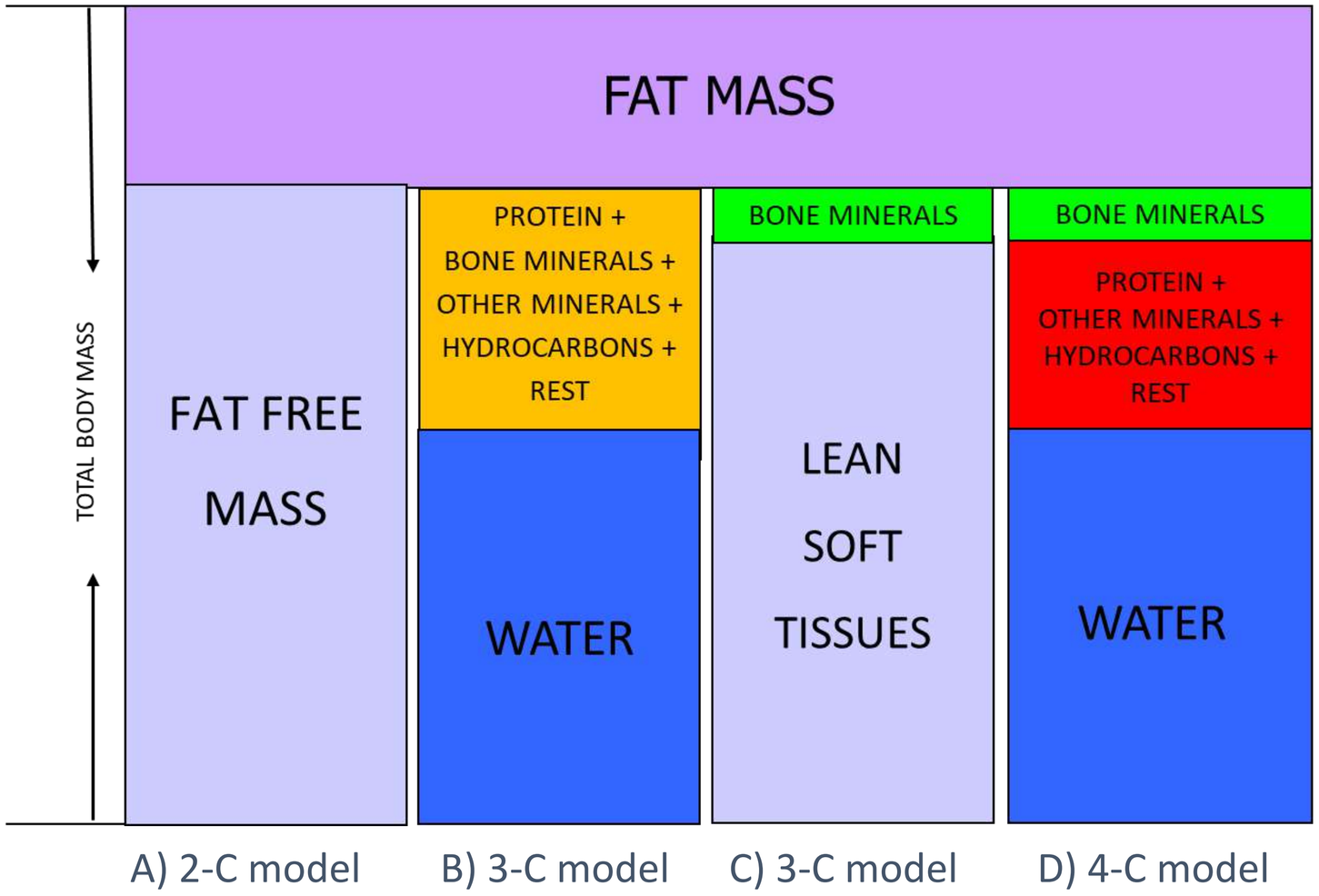
QUESTIONNAIRE

VISCERAL FAT

# BASIC PRINCIPLES OF MEASUREMENT

- The measurement of human body composition is associated with the use of various models, which consider the division of the body into different compartments such as *fat, water, protein, bones, other minerals* etc.
- There are many methods for measuring body composition. A few of them are prototype (max error < ±3% when the body hydration is within normal limits), while the most methods applied are not prototype methods.
- Each prototype method usually measures only one parameter and therefore, one body compartment (the second is deduced by subtracting from the body mass).
- The more prototype methods are used, the less the error is. E.g., for measuring the *%BF* with an accuracy of the order of ±1% we need to apply the 3-C model (see next page), while with the 4-C model the accuracy is better than ±1%.

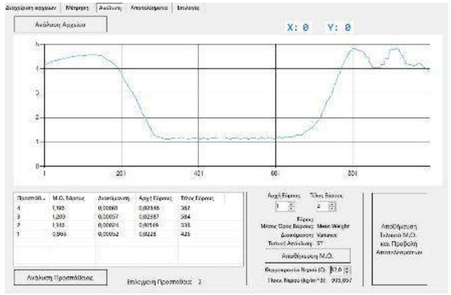
# MOLECULAR LEVEL: 2-, 3- AND 4-COMPARTMENT MODELS




- Currently, we propose the use the 3-C model (case B).
- For subjects who can undergo the whole-body DXA measurement too, the 4-C model is applied (case D).
- Water is further divided in intra-cellular and extra-cellular.

# METHODS USED IN OUR LAB

| | | |
|---|---|---|
| **1** | **Underwater Weighing with synchronous measurement of pulmonary volumes (*FRC, ERV, RV*)** | **Gold-standard method for measuring the density of human body, $D_b$, with high accuracy. $D_b$ is used for the estimation of percent body fat (*%BF*), as well as for applying the 3-C or 4-C molecular model (*fat + water + bone minerals + protein/etc*)** |
| **2** | Plethysmography or The Air Displacement Method or Bod Pod | Another prototype method for measuring $D_b$ with high accuracy. It is used in cases where the subject cannot be submerged in the water (elderly, disabled, children under a certain age etc). |



# METHODS USED IN OUR LAB

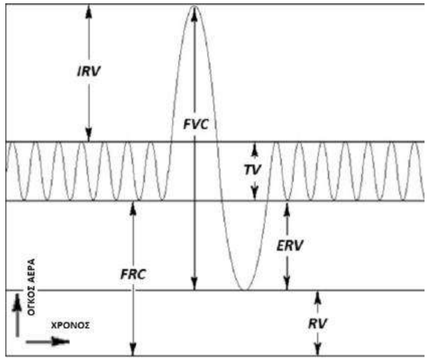
| | | |
|---|---|---|
| 3 | Bioelectrical Impedance Spectroscopy, BIS | The Bioelectrical Impedance of the human body is measured in 256 frequencies. The proper algorithm estimates with high accuracy the intra-cellular water (*ICW*), the extra-cellular water (*ECW*) and the total body water (*TBW*). The *ICW* is correlated to the body-cell mass. The *TBW* together with $D_b$ is used in the 3-Compartment molecular model, which becomes 4-C (*fat + ICW + ECW + protein/minerals*) or even 5-C when the *DXA* method is also applied. |
| | | |

# METHODS USED IN OUR LAB

| | | |
|---|---|---|
| 4 | Dual-Energy X-Ray Absorptiometry, DXA or DEXA | DXA measures the bone minerals with high accuracy.<br>When applied with $D_b$ (methods 1 and/or 2) and TBW (method 3, BIS), we make use of the 5-Compartment model, which provides very accurate measurement of:<br>*fat* + *ICW* + *ECW* + bone minerals + protein/etc. |
| | | |

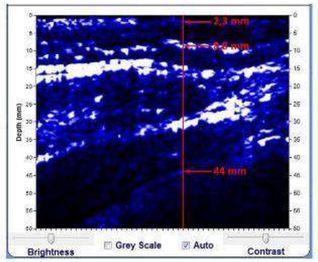
# METHODS USED IN OUR LAB

| | | |
|---|---|---|
| **5** | **Resting Metabolic Rate (*RMR*) or Resting Energy Expenditure (*REE*)** | **Measurement of the resting metabolic rate (*RMR*) via indirect calorimetry (spirometry). Parallel measurement of respiratory quotient (*RQ*). Both *RMR* and *RQ* are useful parameters in the evaluation of the individual's metabolism.** |
| **6** | Palmonary Volumes FRC, ERV, RV etc. | Measurement of pulmonary volumes such as FRC, ERV, RV, the knowledge of which is necessary for applying Underwater Weighing (method 1) and for checking the accuracy of BodPod (method 2). |
| | | |



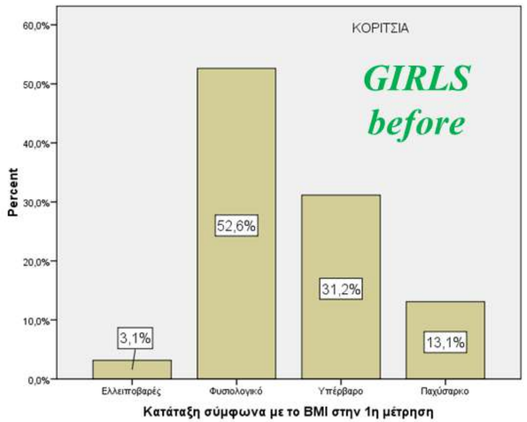
# METHODS USED IN OUR LAB

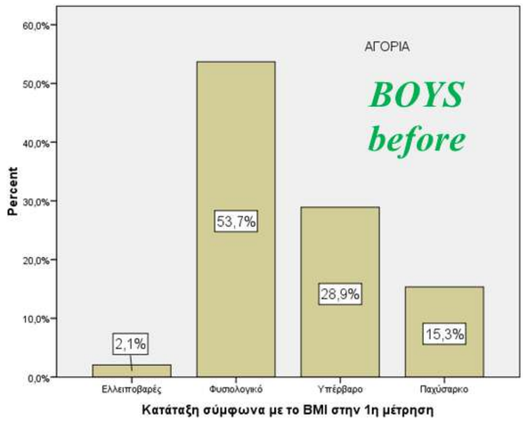
| | | |
|---|---|---|
| **7** | **Ultrasonics** | **Measurement of the various skinfolds with grate accuracy. Embedded equations directly provide the %BF after measuring a number of preset skinfolds.** |
| **8** | Accelerometers - pedometers | Measurement of physical activity. When applied together with RMR, we can accurately estimate the total energy expenditure or the daily energy consumption. Together with the questionnaire analysis, it is possible to accurately estimate the daily energy balance. |
| **9** | Other methods | In certain cases, and under various conditions (e.g. in outdoors, schools etc.) other methods are also used such as simple *BIA* (1- 2- or 4-frequencies), *BIA* in abdomen, *NIR*, Skin-folds using calipers etc. |

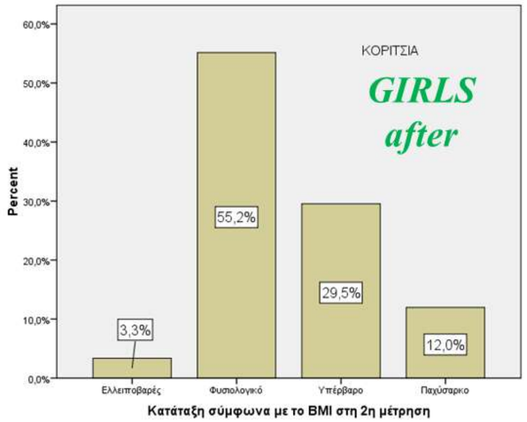


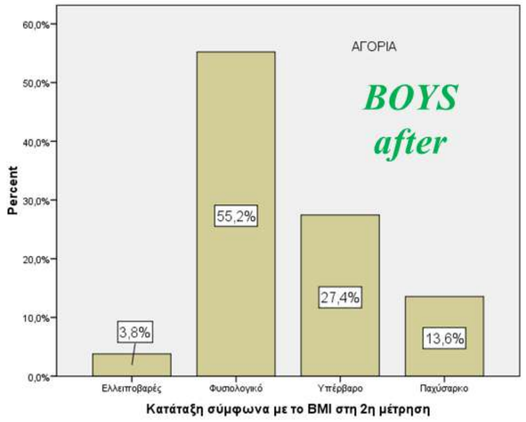

# USING BODY COMPOSITION IN INTERVENTION

**By using the *BMI* as an indicator for evaluating the outcome of an intervention, it is impossible to identify any changes.**

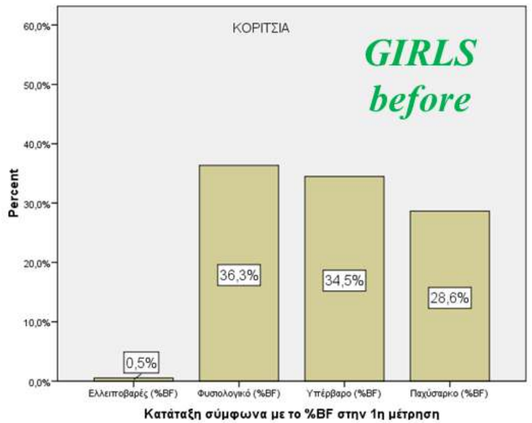


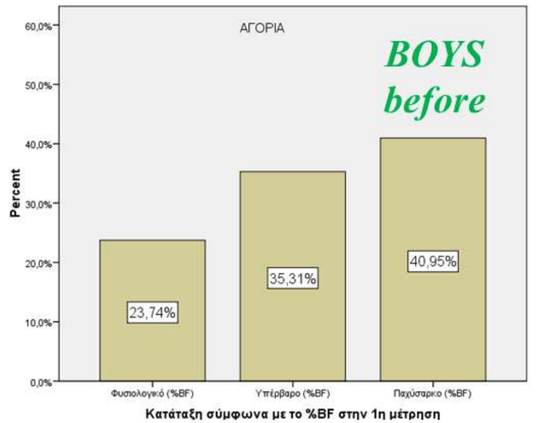



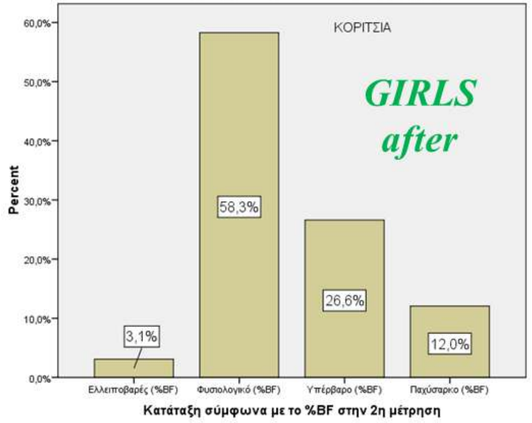



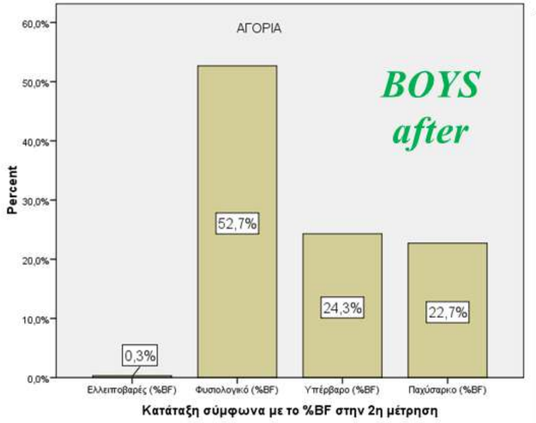




**By using the *%BF* for the same reason, the success of the interventions becomes obvious!**



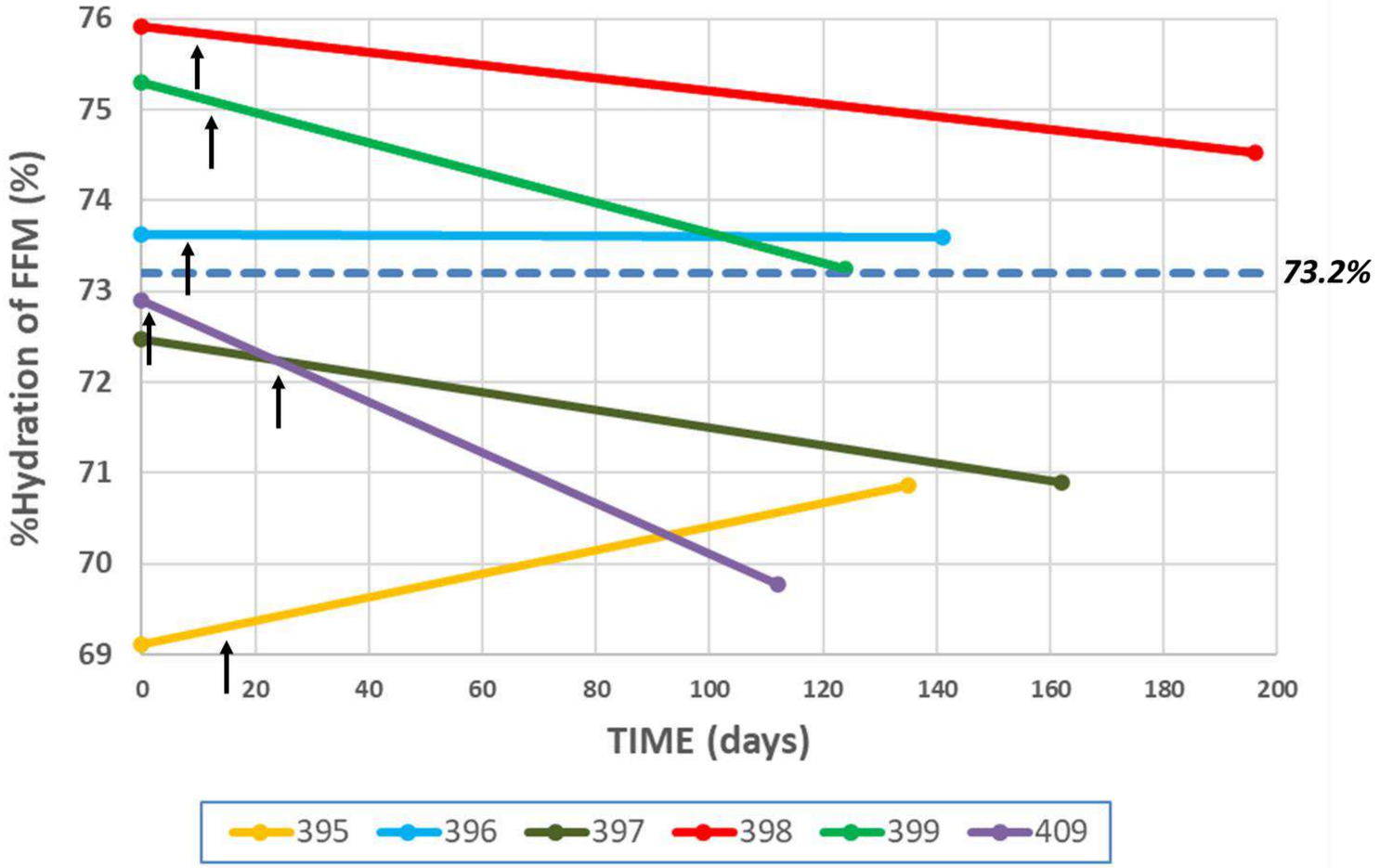



# USING BODY COMPOSITION IN INTERVENTION

**Independent Samples Test**

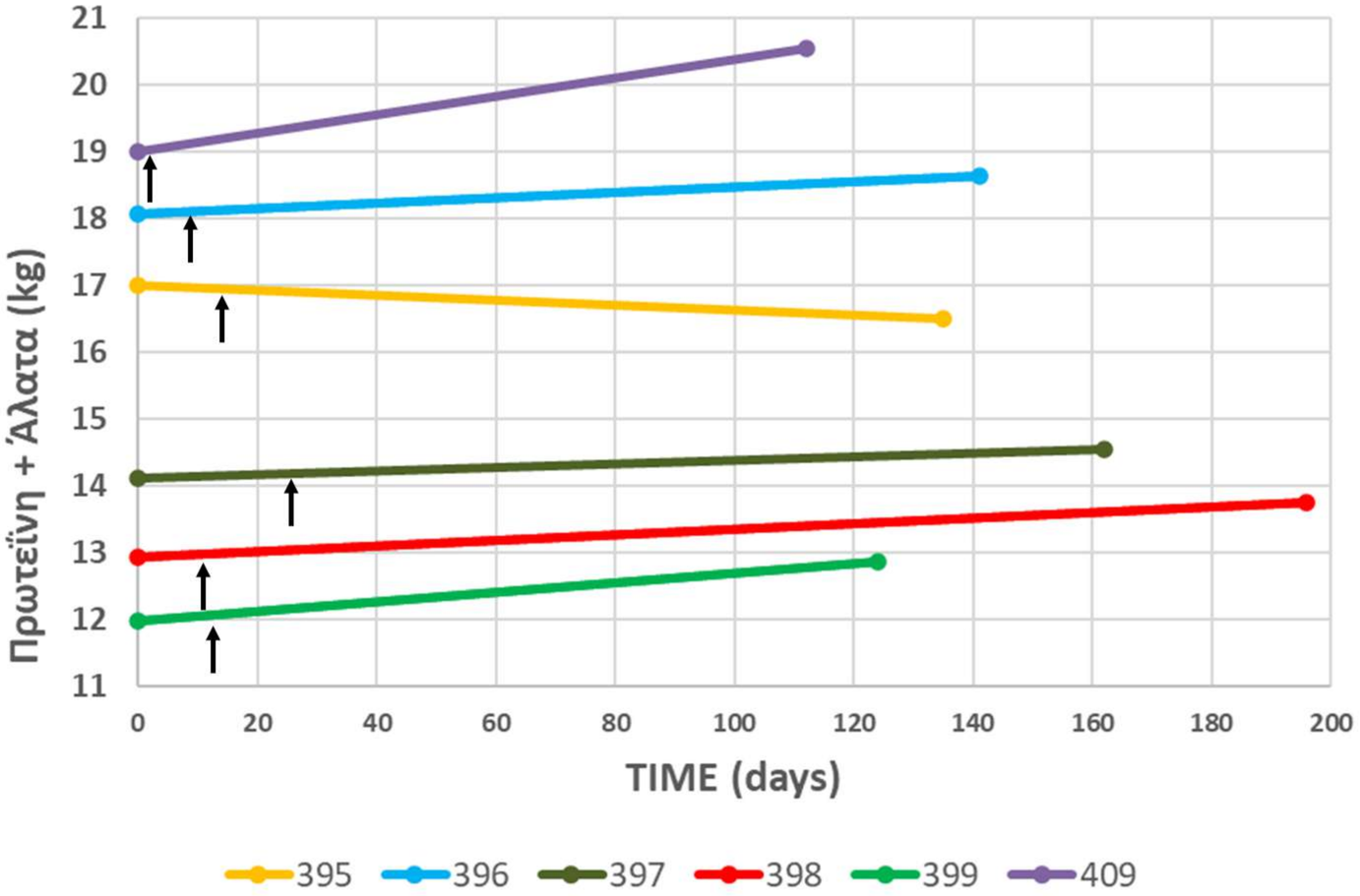
| | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 95% Confidence Interval of the Difference | |
| | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Μεταβολή του %BF (NIR) | 3,250 | ,073 | -,213 | 266 | ,831 | -,04346 | ,20402 | -,44516 | ,35825 |
| | | | -,191 | 83,462 | ,849 | -,04346 | ,22693 | -,49478 | ,40787 |
| Μεταβολή του %BF calc (BIS) | 1,440 | ,231 | -5,300 | 532 | ,000 | -1,81419 | ,34232 | -2,48666 | -1,14172 |
| | | | -5,326 | 199,649 | ,000 | -1,81419 | ,34062 | -2,48586 | -1,14252 |
| Μεταβολή του %ICF calc (BIS) | 1,840 | ,175 | 3,168 | 532 | ,002 | ,42004 | ,13259 | ,15957 | ,68050 |
| | | | 2,217 | 137,673 | ,028 | ,42004 | ,18948 | ,04537 | ,79471 |
| Μεταβολή περιμέτρου μέσης | 1,771 | ,184 | ,124 | 538 | ,902 | ,03531 | ,28529 | -,52510 | ,59572 |
| | | | ,134 | 223,847 | ,894 | ,03531 | ,26360 | -,48415 | ,55477 |
| Μεταβολή περιμέτρου βραχίονα | 5,291 | ,022 | 3,038 | 543 | ,002 | ,33040 | ,10875 | ,11677 | ,54402 |
| | | | 3,772 | 293,792 | ,000 | ,33040 | ,08759 | ,15801 | ,50278 |
| Μεταβολή του τρικεφάλου | 20,758 | ,000 | -4,232 | 532 | ,000 | -1,61863 | ,38246 | -2,36994 | -,86731 |
| | | | -5,226 | 286,483 | ,000 | -1,61863 | ,30970 | -2,22821 | -1,00904 |
| Μεταβολή RMR (ένδειξη NIR) | 3,885 | ,050 | ,098 | 263 | ,922 | ,78090 | 7,98502 | -14,94181 | 16,50360 |
| | | | ,144 | 215,751 | ,886 | ,78090 | 5,42403 | -9,90998 | 11,47177 |
| Μεταβολη ύψους προς μεσοδιάστημα μετρήσεων dh/dt | ,643 | ,423 | -,270 | 539 | ,787 | -,0007872 | ,0029146 | -,0065125 | ,0049381 |
| | | | -,256 | 185,223 | ,798 | -,0007872 | ,0030716 | -,0068470 | ,0052725 |

# PERCENT HYDRATION OF FAT FREE MASS




- In four out of six kidney disease patients, the hydration changed towards the recommended value of 73,2%

# PROTEIN CHANGE




- We observe an increase in five out of six cases.
- In case 395 there is a decrease in protein but at the same time we have an increase in hydration towards the recommended value (see next Figure).

# OUR RESEARCH TEAM

**PERMANENT TEACHING/RESEARCH STAFF**

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*of our Department*

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# THANK YOU FOR YOUR ATTENTION