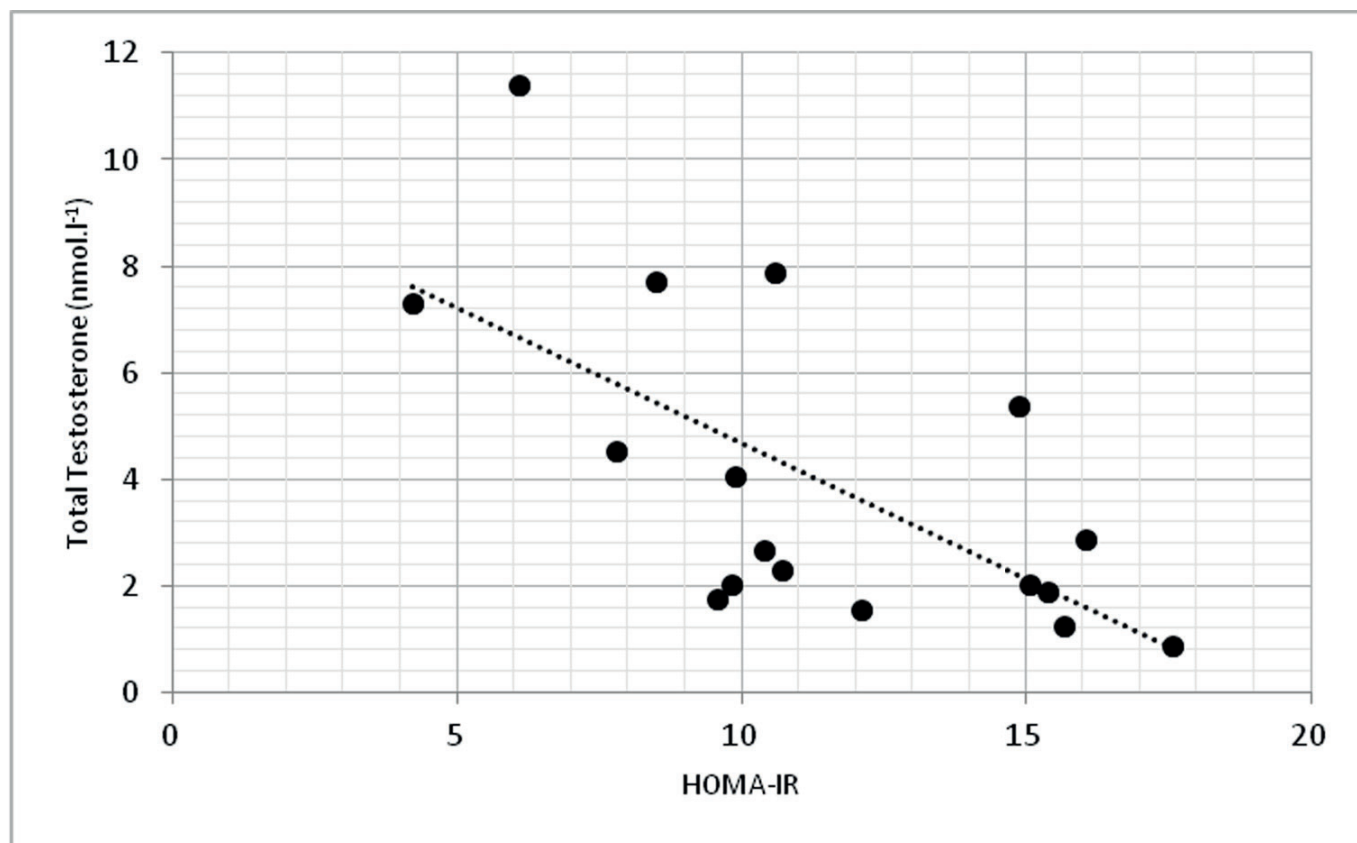


Fig. 4. Relationship between total testosterone levels and HOMA-IR ($r = -0.623$, $p < 0.01$)

minutes at 4°C no later than 60 minutes after the blood draw to generate a serum and immediately transported to the accredited medical laboratory for further analyses. The parameters analysed from serum were glucose, total cholesterol, LDL-cholesterol, HDL-cholesterol, total testosterone (TT), SHBG, insulin, homeostasis model assessment of insulin resistance (HOMA-IR) and cortisol.

Results

Due to limited number of subjects, 2-tailed Spearman's correlation coefficient was used. TT had statistically significant inverse correlation with abdominal circumference at $p < 0.01$, $r = -0.639$ (fig. 1). TT was inversely correlated with overall body fat, measured in kilograms at $p < 0.01$, $r = -0.762$ (fig. 2).

On a biochemical level, significant correlations were found in TT and insulin ($p < 0.01$, $r = -0.674$) (fig. 3) and TT with homeostasis model assessment of insulin resistance (HOMA-IR) at $p < 0.01$, $r = -0.623$ (fig. 4).

Discussion

The study aimed to investigate the relationship between testosterone, body composition, physical function selected biochemical parameters. In our findings, low level of total testosterone correlated with abdominal circumference as a sign of higher change of obesity. These findings agree with (9). They found that abdominal circumference (AC) was inversely correlated with total testosterone ($p = 0.006$) in 159 patients with hypogonadism. Relationship between AC and TT lead to conclusion, that AC could help to ease the identification of males with low TT levels. Some authors showed relationship between total

testosterone and BMI (12), but in our group this correlation was not significant. The correlation between TT and BMI was not that strong and significant as for the abdominal circumference. However, when overall body fat mass was measured in kilograms, we found significant inverse correlation ($p < 0.01$), which also correspond with other studies (1) as one of the primary sign of low TT levels.

On biochemical level, we found significant correlations between total testosterone and insulin ($p < 0.01$) and HOMA-IR ($p < 0.01$), which can indicate higher incidence of type 2 diabetes and obesity. Similar findings demonstrated also other works with hypogonadal males (13).

The interesting finding of our study was that there was no significant correlation between TT levels and muscle strength, lean mass or physical function in middle age males. These findings are in contradiction to some studies (1,14) which named reduction in lean mass, muscle strength and decreased energy or vitality as one of the primary symptoms of low testosterone levels. Some authors (1) stated that changes in muscle strength in older men correlated with total ($r = 0.51$; $P < 0.001$) and free ($r = 0.44$; $P < 0.001$) testosterone levels. However, the above r values do not suggest strong correlation of the studied parameters (15), also found that under physiological conditions, testosterone is associated with significant rise in muscle mass providing maximal voluntary strength and decreased fat mass.

In addition, (16) did not find strong correlation between TT and muscle strength and stated that the effects of TT on muscle strength in older men are inconsistent. Some studies in healthy older men have reported improvements in grip strength with higher TT levels. The improvements in strength may be dependent on muscle groups.