Journal of Physical Activity and Health, 2016, 13, 467-473
http://dx.doi.org/10.1123/jpah.2015-0378

Human Kinetics
ORIGINAL RESEARCH

Longitudinal Study on the Association Between Cardiorespiratory Fitness, Anthropometric Parameters and Blood Lipids

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Background: Longitudinal evidence concerning the association between cardiorespiratory fitness (CRF) and blood lipids and between anthropometric parameters (ANTP) and blood lipids is limited. This study aimed to investigate the association between changes in CRF and ANTP and changes in blood lipids. **Methods:** In 2002–2004 and 2012–2014, 652 participants were tested. CRF was measured as VO_2peak using a maximal ergometer test. Waist circumference (WC) and Body Mass Index (BMI) were used as ANTP. Blood samples were analyzed for total cholesterol (TC), HDL cholesterol, LDL cholesterol and triglycerides. A linear regression analysis was performed to investigate associations between changes in CRF and ANTP and changes in blood lipids. **Results:** After adjustment a decrease in CRF was associated with an increase in triglycerides and a decrease in HDL cholesterol in men. An increase in WC was associated with an increase in TC, LDL cholesterol and ratio total/HDL cholesterol and a decrease in HDL cholesterol, while an increase in BMI was associated with an increase in ratio total/HDL cholesterol and a decrease in HDL cholesterol. **Conclusions:** WC and BMI were more longitudinally associated with blood lipids compared with CRF. Improving ANTP can enhance the blood lipid profile, while CRF had only limited influence.

Keywords: blood cholesterol, VO_2peak, body mass index, waist circumference

Although cardiovascular heart disease (CHD) is a main cause of death,[1] the contribution of cardiorespiratory fitness (CRF) and anthropometric parameters (ANTP) to CHD indicators such as blood lipids is still controversial.[2] Very few longitudinal studies have investigated the role of objectively measured CRF and ANTP in combination with circulating levels of blood lipids. Lee et al[2] found that an increase in CRF over a 6-year follow-up period was associated with an increase in HDL cholesterol and a decrease in TC and triglycerides. Furthermore, the CARDIA study found that improving CRF was not associated with decreasing LDL cholesterol over a 15-year follow-up period.[3] An increase in Body Mass Index (BMI) over a 6-year follow-up period was associated with an increase in TC and triglycerides and a decrease in HDL cholesterol.[2] Kaess et al[4] demonstrated that an increase in BMI and waist circumference (WC) were associated with a drop in HDL cholesterol and an increase in triglycerides over a 2-year follow-up period. While previous studies have provided important information, a limitation of these studies is that analyses were mostly corrected for but not stratified by gender. CRF, ANTP and blood lipids differ between men and women,[5] while associations between those parameters may also be gender-specific. As a consequence, analyses stratified by gender may deliver more refined results taking into account these complex interrelationships. Findings of the few existing longitudinal studies are not all in the same line, possibly because of different measures or parameters of CRF and ANTP, diverse follow-up periods and different levels of correction for confounding factors. Parameters such as age,[6] smoking,[7] physical activity level (PAL),[8,9] and sedentary behavior[10] can have an influence on the blood lipid profile.

Regarding ANTP it is still not clear to what extent an increase in central adiposity or total adiposity is associated with a deteriorating blood lipid profile. Cross-sectional studies have shown that the distribution of fat is recognized as important, with central adiposity conferring higher disease risk.[11,12]

The longitudinal association between CRF and ANTP and the blood lipid profile needs further examination. The main aim of the current study was to investigate the longitudinal associations between CRF and blood lipids and between ANTP and blood lipids over a 10-year follow-up period, stratified by gender. In addition, we wanted to investigate these associations as a function of different ANTP: WC and BMI respectively. As central adiposity was found to confer higher disease risk in previous research,[11,12] it was hypothesized that there would be a stronger association between changes in the central adiposity component (WC) and blood lipids compared with changes in total adiposity (BMI).

Methods

Subjects

Data were gathered by the Flemish Policy Research Centre Sport, Physical Activity and Health.[13] This Research Centre aimed to investigate health behaviors, physical fitness and mental health among an adult population. For this purpose, the National Institute of Statistics selected 46 Flemish municipalities by clustered random sampling. Within the municipalities, a random sample of men and women between 18 and 75 years old was selected in 2002. Although small differences were observed, the sample can be considered as representative for geographic distribution, age, gender and educational level. The first test moment took place during 2002–2004, the second test moment during 2012–2014. As much as possible the same tests and measures performed at the first assessment (2002–2004) were repeated at the second assessment (2012–2014), although not every participant performed the test twice because of

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technical or organizational problems or because of their risk profile. Of the original 1569 participants in 2002–2004, 420 men and 232 women returned for participation in 2012–2014. All participants signed an informed consent. The study was approved by the ethical and medical committee of the KU Leuven.

Tests and Measures

Blood Samples. Participants were instructed to fast from 11:00 PM the evening before their visit. A fasting blood sample was taken. TC, HDL cholesterol, LDL cholesterol and triglyceride were determined. Triglyceride was analyzed using the lipase/glycerol kinase/glycerol phosphate oxidase enzymatic method. HDL cholesterol was analyzed using the homogeneous polyanion/cholesterol esterase/oxidase enzymatic method. Triglyceride and HDL cholesterol were measured on an Olympus AU5400 analyzer (Olympus Diagnostica, Hamburg, Germany). LDL cholesterol was calculated using the following formula: LDL cholesterol = (TC – HDL cholesterol – Triglycerides) ÷ 5.[14]

Cardiorespiratory Fitness. CRF was measured using a maximal exercise test on an electrically braked cycle ergometer (Lode, Groningen, The Netherlands) applying a standardized exercise protocol. The test started with a workload of 20 Watt, which increased with 20 Watt per minute. Participants were asked to cycle at about 70 rpm. The test leader encouraged them to reach their level of exhaustion. A Cortex Metalyser 3B Analyzer (Cortex Biophysic GmbH, Leipzig, Germany) was used to measure oxygen consumption with breath-by-breath respiratory gas exchange analysis. This method generates highly reliable results.[15] CRF was assessed as peak oxygen uptake normalized for body weight (VO_2peak in ml/kg/min). For this test a medical screening was required, with participants being excluded using the following criteria: hypertension, aortic stenosis, good clinical judgment, exclusion after electrocardiogram, joint degradation in ankle or knee, and exclusion based on family history.[16–18]

Anthropometric Parameters. Anthropometry was performed by trained staff using standardized techniques and equipment.[19] Participants were measured barefoot and in minimal clothing. WC and BMI were used as ANTP. WC was measured using a metal tape (Rosscraft, Surrey, BC, Canada) at the narrowest level between lowest ribs and iliac crests to the nearest 0.1 cm. Body weight was recorded to the nearest 0.1 kg with a digital weight scale (Seca 841, Seca GmbH, Hamburg, Germany) and body height with a stadiometer (Holtain, Crymych, UK) to the nearest 0.1 cm. BMI was calculated using the following formula: BMI = body weight (kg) ÷ [height (m)]^2.

Smoking Behavior. Smoking behavior was assessed using the WHO Monica Smoking Questionnaire.[20] According to their responses, participants were classified into actual smokers or nonsmokers.

Energy Intake. Participants completed a 3-day diet record, in which they recorded all foods and drinks during 2 weekdays and 1 weekend day.[21] They were asked to weigh the amount of foods and drinks consumed if possible. Otherwise they were inquired to estimate the amount of the foods and drinks by using standard household measures (eg, glass, spoon, etc). The diet records were analyzed using Becel Nutrition software (Unilever Co.; Rotterdam, The Netherlands). Total energy intake (in kcal/day) was computed.

Screen Time. Screen time was estimated using the Flemish Physical Activity Questionnaire (FPACQ)[22] and was used as a sedentary behavior parameter. Participants were asked to report time spent watching video/television or playing computer games during an average week day and weekend day. Screen time was calculated by multiplying the average week day scores by 5 and the weekend scores by 2, then summing both scores and dividing by 7 to obtain average hours of screen time per day.

Physical Activity Assessment. PAL was estimated using the FPACQ. The FPACQ was found to be a valid and reliable questionnaire for different components of physical activity (PA) during a normal week in adults.[22] PAL is an indicator of the general activity level. The PAL expresses the PA of a person as a number and is calculated by dividing the total energy expenditure per week by 168 (the number of hours per week). Total energy expenditure per week is calculated by summing the energy spent on working, household activities, leisure time activities, sleeping and eating, based on intensity and duration of activity.

Statistical Analysis

SPSS 21.0 (SPSS Inc. Chicago, IL) statistics software was used for data analysis. Normality of data were checked visually and with Kolmogorov-Smirnov test. Data were mostly normally distributed. Nonnormally distributed data were tested with parametric and nonparametric tests, but this had no influence on the nature of the relationships. For clarity and simplicity only the results of the parametric tests were presented. A drop-out analysis was performed by comparing baseline results between the follow-up group and the group that only participated in 2002–2004 using an independent samples *t*-test. A paired samples *t*-test was used for characterization of the participants and to examine if there are any differences in parameters between the 2 test moments. Differences in percentage actual smokers between the 2 test moments were investigated using the chi-square test. Changes in VO_2peak, WC, BMI, smoking, total energy intake, screen time and PAL between the test periods were calculated using residual change scores. Residual change scores were created by regressing the follow-up measures onto their respective baseline measures. The residualized change scores can be interpreted as the amount of change between the first and second test moment, independent of baseline levels and are preferable to simple change scores because they eliminate auto-correlated error and regression to the mean effects.[23] Associations between changes in ANTP, CRF and changes in blood lipids were tested in an unadjusted model using multivariate linear regression with blood lipids as continuous dependent variable. In an adjusted model the analyses were adjusted for possible confounders, such as age and changes in respectively smoking, energy intake, screen time and PAL. After checking for multicollinearity, changes in WC were used as confounder in the longitudinal association between CRF and blood lipids, and changes in CRF were used as confounder in the longitudinal association between ANTP and blood lipids. The analyses were stratified by gender. A 2-sided 0.05 level of significance was defined.

Results

In a drop-out analysis ANTP, PAL, screen time, CRF and blood lipids were used to assess representativeness of the present sample compared with those who dropped-out (Table 1). In women, the present sample scored significantly better on BMI, WC, PAL, VO_2peak, HDL cholesterol, and ratio total/HDL cholesterol compared with women who dropped-out. In men, the present sample scored significantly better on ratio total/HDL cholesterol and triglycerides compared with men who dropped-out.

In Table 2 characteristics of participants are presented, as well as test results of the first (2002–2004) and second (2012–2014)

Table 1 Drop-out Analysis: Comparison of Variables Between Drop-outs and Follow-ups by Baseline Measure in Adults Aged 18–75 Years,* Policy Research Centre Sport Leuven, 2002–2004

	Men					Women				
	Drop-out (N = 503)		Follow-up (N = 420)			Drop-out (N = 414)		Follow-up (N = 232)		
	N	Mean (SD)	N	Mean (SD)	*P*	N	Mean (SD)	N	Mean (SD)	*P*
Body mass index (kg/m²)	501	25.7 (3.4)	420	25.4 (2.8)	0.148	411	24.6 (4.2)	232	23.5 (3.2)	<0.001
Waist circumference (cm)	500	89.5 (10.4)	420	89.2 (8.8)	0.595	411	77.9 (10.0)	232	75.7 (7.6)	0.001
Physical activity level	484	1.8 (0.3)	399	1.8 (0.2)	0.247	406	1.7 (0.2)	223	1.7 (0.2)	0.008
Screen time (hours/day)	484	2.1 (1.3)	399	2.0 (1.1)	0.120	406	1.8 (1.2)	223	1.8 (1.1)	0.927
VO_2peak relative (ml/kg/min)	434	36.9 (9.0)	389	37.5 (8.1)	0.331	380	27.2 (6.3)	218	29.3 (6.1)	<0.001
Total cholesterol (mg/dl)	495	209.1 (41.4)	418	206.0 (37.5)	0.234	412	203.3 (36.4)	231	205.2 (38.8)	0.539
HDL cholesterol (mg/dl)	495	54.4 (12.5)	418	55.5 (11.7)	0.157	412	65.7 (14.8)	231	70.0 (15.4)	<0.001
LDL cholesterol (mg/dl)	495	130.3 (36.5)	418	128.0 (33.8)	0.329	412	118.5 (32.0)	231	116.1 (35.0)	0.377
Ratio total/HDL cholesterol	495	4.0 (1.1)	418	3.9 (1.0)	0.027	412	3.2 (0.8)	231	3.1 (0.9)	0.016
Triglycerides (mg/dl)	495	122.4 (84.1)	418	111.8 (66.4)	0.033	412	93.9 (43.1)	231	93.3 (42.1)	0.877

Note. Differences in variables between the drop-outs and the follow-ups were tested with an independent samples *t*-test. There were missing values in VO_2peak relative due to risk profile, while missing values in other variables were due to technical or organizational problems.

* Drop-out men = 503, follow-up men = 420, drop-out women = 414, follow-up women = 232.

Table 2 Characteristics of the Participants: Comparison of Variables Between the 2 Test Moments in Adults Aged 18–75 Years at Baseline and 28–85 Years at Follow-up (Men = 420, Women = 232), Policy Research Centre Sport Leuven, 2002–2004 and 2012–2014

	Men (N = 420)					Women (N = 232)				
		2002–2004	2012–2014				2002–2004	2012–2014		
	N	Mean (SD)	Mean (SD)	Change	*P*	N	Mean (SD)	Mean (SD)	Change	*P*
Age (years)	420	46.7 (10.3)	57.3 (10.3)	–10.6	<0.001	232	44.6 (8.9)	55.2 (8.9)	–10.6	<0.001
Body Mass Index (kg/m²)	420	25.4 (2.8)	25.8 (3.1)	–0.4	<0.001	232	23.5 (3.2)	24.3 (3.6)	–0.8	<0.001
Waist circumference (cm)	420	89.2 (8.8)	90.2 (9.0)	–1.0	<0.001	232	75.7 (7.6)	78.0 (8.7)	–2.3	<0.001
Physical Activity Level	391	1.8 (0.2)	1.8 (0.3)	0.0	0.007	216	1.7 (0.2)	1.7 (0.2)	0.0	0.418
Screen time (hours/day)	391	2.0 (1.1)	2.3 (1.2)	–0.3	<0.001	216	1.8 (1.1)	2.1 (1.2)	–0.3	<0.001
Energy intake (kcal/day)	373	2590.3 (672.7)	2421.4 (622.1)	168.9	<0.001	197	2037.5 (512.2)	1961.9 (541.8)	75.6	0.060
VO_2peak relative (ml/kg/min)	314	38.4 (7.9)	37.2 (8.7)	1.2	0.001	184	29.6 (6.2)	28.0 (6.1)	1.6	<0.001
Total cholesterol (mg/dl)	410	206.4 (37.6)	206.0 (38.3)	0.4	0.806	227	204.7 (38.5)	222.3 (36.1)	–17.6	<0.001
HDL cholesterol (mg/dl)	410	55.5 (11.7)	53.7 (11.6)	1.8	<0.001	227	70.3 (15.3)	68.9 (15.1)	1.4	0.123
LDL cholesterol (mg/dl)	410	128.1 (33.8)	130.6 (33.8)	–2.5	0.114	227	115.8 (35.1)	134.7 (31.5)	–18.9	<0.001
Ratio total/HDL cholesterol	410	3.9 (1.0)	4.0 (1.1)	–0.1	0.003	227	3.0 (0.9)	3.4 (0.9)	–0.4	<0.001
Triglycerides (mg/dl)	410	111.1 (66.9)	109.4 (72.8)	1.7	0.447	227	92.1 (39.5)	95.2 (52.4)	–3.1	0.332
	N	%	%		*P* chi²	N	%	%		P chi²
Actual smokers (%)	410	14.3	9.1	5.2	<0.001	227	13.4	7.9	5.5	<0.001

Note. Differences in variables between the 2 test periods were tested with a paired samples *t*-test. Differences in actual smokers between the 2 test periods were calculated with a chi-square test. There were missing values in VO_2peak relative due to risk profile, while missing values in other variables were due to technical or organizational problems.

assessment. The mean (SD) age at the first assessment was 46.7 (10.3) years in men and 44.6 (8.9) years in women. At the second assessment the mean (SD) was 57.3 (10.3) years in men and 55.2 (8.9) years in women. In men, BMI, WC, screen time, and ratio total/HDL cholesterol increased, while PAL, energy intake, VO_2peak and HDL cholesterol decreased over the 2 assessments. In women, BMI, WC, screen time, TC, LDL cholesterol, and ratio total/HDL cholesterol increased, while VO_2peak decreased over the 2 assessments.

The multivariate linear regression analysis with residual change score in blood lipids as dependent variable and residual change score in CRF as independent variable is presented in Table 3. The unadjusted model (model 1) illustrates that a mean decrease in VO_2peak was associated with an increase in triglycerides in men and women, and with an increase in ratio total/HDL cholesterol and a decrease in HDL cholesterol in men. This means that for every 1-unit decrease in VO_2peak, triglycerides will increase with respectively 0.215 mg/dl and 0.153 mg/dl in men and women. After adjustment for potential confounders (model 2) a mean decrease in VO_2peak was associated with an increase in triglycerides in men and women and with a decrease in HDL cholesterol in men. This means that for every 1-unit decrease in VO_2peak, triglycerides will increase with 0.217 mg/dl in men and with 0.184 mg/dl women and HDL cholesterol will decrease with 0.332 mg/dl in men after adjustment for potential confounders (model 2).

The multivariate linear regression analysis with residual change score in blood lipids as dependent variable and residual change score in ANTP as independent variable is presented in Table 4. In the unadjusted model (model 1), a mean increase in WC was associated with an increase in TC, LDL cholesterol, ratio total/HDL cholesterol and with a decrease in HDL cholesterol in men and women and with an increase in triglycerides in men. A mean increase in BMI was associated with an increase in TC, LDL cholesterol, ratio total/HDL cholesterol, triglycerides, and with a decrease in HDL cholesterol in men and women. After adjustment for potential confounders (model 2) a mean increase in WC was associated with an increase in TC, LDL cholesterol, ratio total/HDL cholesterol, and with a decrease in HDL cholesterol in men and women and with an increase in triglycerides in men. A mean increase in BMI was associated with an increase in ratio total/HDL cholesterol and with a decrease in HDL cholesterol in men and women and with an increase in TC and LDL cholesterol in women. In men, WC showed more and stronger longitudinal associations with blood lipids compared with BMI.

Discussion

This study investigated the associations between changes in CRF and ANTP and changes in blood lipids over a 10-year follow-up period. To evaluate the effect of potential confounders, unadjusted and adjusted analyses were performed, stratified by gender.

ANTP was more strongly associated with blood lipids compared with CRF, both in the adjusted and the unadjusted analyses and both in men and women. CRF was only poorly longitudinally associated with blood lipids, with slightly more associations found in men compared with women, both in the unadjusted and the adjusted analysis. The paucity of longitudinal associations between CRF and blood lipids and the low explained variance of the predictor variables can be attributed to different factors. CRF is a combination of genetic aspects, PA and functional health of several organ systems.[24] There is a wide variability in the response to CRF, which is interindividual and under environmental control.[25] In addition, other factors such as diet, inflammation, oxidative stress, immune dysfunction and genetic parameters may be underlying causes of hyperlipidemia.[26] Another possible explanation for the few longitudinal associations may be the health status of the participants. The drop-out analysis showed that especially in women volunteers who participated at follow-up had a significantly higher baseline fitness level compared with those who dropped-out. Possibly the change scores were too small to detect longitudinal associations with blood lipids.

Comparing our results with those of previous longitudinal research is difficult, because in other studies the analyses were mostly corrected for and not stratified by gender and mostly a smaller age range was included. The results of the adjusted longitudinal analysis between CRF and blood lipids are in accordance with those from the CARDIA study, where CRF was not longitudinally associated with LDL cholesterol after adjustment for potential confounders.[3] The favorable longitudinal association between CRF and TC, triglycerides, and HDL cholesterol found in the study of Lee et al[2] was only partly confirmed in the current study, possibly because of the longer duration of the follow-up period in combination with the level of controlling for confounders. In the study of Lee et al[2] the analyses were adjusted for age, gender, changes in percentage body fat and dummy variables for changes in physical activity, smoking status and alcohol intake, while in the current study the analyses were also adjusted for changes in energy intake and screen time but not for alcohol intake.

In contrast with CRF, changes in WC (both in men and women) and BMI (mainly in women) were more strongly associated with changes in blood lipids after adjustment for potential confounders. Since BMI does not take into account the distribution between fat mass and fat free mass, its value in relation to health is often questioned.[27] However, in this longitudinal design with an on average middle-aged population an increase in BMI is most probably attributed to an increase in fat mass. The latter may explain its value in the longitudinal association with blood lipids. An increase in the ANTP, both in men and women and both in the nonadjusted and the adjusted analysis, was significantly associated with an increase in ratio total/HDL cholesterol. Ratio total/HDL cholesterol is considered as a crucial cardiovascular health parameter[28] but was despite its importance not included in previous longitudinal research. For health promotion this finding can be meaningful, since ANTP can be improved with sustained low- to moderate-intensity exercise and daily PA, while improvement of CRF is also possible with moderate-intensity exercise but requires more high-intensity training to achieve greater results.[29] High-intensity training programs also show higher drop-out rates and injury incidence.[29] Weight loss and fat oxidation can also be accomplished by regular participation in low- to moderate-intensity exercise which generally shows long-term adherence.[30] In general findings from the current study are in agreement with previous longitudinal research,[2,4] where a decrease in ANTP is associated with a deteriorating blood lipid profile.

We also compared associations with blood lipids between the central adiposity component (assessed by WC) and the total adiposity component (assessed by BMI). We could only partly confirm the proposed hypothesis that changes in the central adiposity component would be more associated with changes in blood lipids compared with changes in total adiposity. The results of the current study indicate that in men an increase in WC was strongly associated with a deteriorated blood lipid profile after adjustment for potential confounders. In women both changes in WC and BMI were equally associated with changes in blood lipids after adjustment for potential confounders.

There are some limitations to this study. Since on average healthier people tend to participate in health-related research projects,[31] the external validity may be limited. Selective drop-out toward the second measurement has implications for the internal and external validity. However, drop-out is a typical phenomenon in longitudinal studies.[32] Because of the selective sample, findings of the current study may not be applicable to less healthy or unhealthy populations. Another limitation is that we could not adjust for environmental factors, cholesterol medication and menopausal status in women, because this information was not available. Also the fact that BMI is used as an indicator for total adiposity is a limitation, as it does not distinguish lean mass and fat mass. However, BMI has proven to be a useful parameter in the association with health,[33,34] although the use of more recently developed devices such as Bodpod as an estimate of body fat percentage would provide additional information. The strengths of the current study are the longitudinal study design with a follow-up period of 10 years in adults with a wide age range (between 18 and 75 years old at baseline), the inclusion of strong objective measures at both

Table 3 Multivariate Linear Regression Analysis With Residual Change Score in Blood Lipids as Dependent Variable and Residual Change Score in Cardiorespiratory Fitness (VO_2peak) as Independent Variable in Adults Aged 18–75 Years at Baseline and 28–85 Years at Follow-up (Men = 420, Women = 232), Policy Research Centre Sport Leuven, 2002–2004 and 2012–2014

	Men					Women				
	Model 1		Model 2			Model 1		Model 2		
	β	R^2	β	B	SE	β	R^2	β	B	SE
RCS VO_2peak (ml/kg/min) – RCS Total cholesterol (mg/dl)	–0.068	0.5%	–0.080	–0.072	0.059	–0.077	0.6%	–0.095	–0.112	0.104
RCS VO_2peak (ml/kg/min) – RCS HDL cholesterol (mg/dl)	0.365***	13.3%	0.332***	0.253	0.047	0.066	0.4%	–0.004	–0.006	0.134
RCS VO_2peak (ml/kg/min) – RCS LDL cholesterol (mg/dl)	–0.098	0.8%	–0.096	–0.090	0.062	–0.060	0.4%	–0.034	–0.042	0.108
RCS VO_2peak (ml/kg/min) – RCS Ratio total/HDL cholesterol	–0.231***	5.3%	–0.243**	–0.260	0.068	–0.116	1.3%	–0.069	–0.068	0.087
RCS VO_2peak (ml/kg/min) – RCS Triglycerides (mg/dl)	–0.215***	4.6%	–0.217**	–0.261	0.078	–0.153*	2.3%	–0.184*	–0.206	0.095

* $P < .05$; ** $P < .01$; *** $P < .001$.

Abbreviations: RCS, residual change score.

Note. Model 1: unadjusted. Model 2: adjusted for age, residual change score smoking, residual change score energy intake, residual change score screen time and residual change score Physical Activity Level. There were missing values in VO_2peak relative due to risk profile, while missing values in other variables were due to technical or organizational problems.

Table 4 Multivariate Linear Regression Analysis With Residual Change Score in Blood Lipids as Dependent Variable and Residual Change Score in Anthropometric Parameters (Waist Circumference and Body Mass Index) as Independent Variable in Adults Aged 18–75 years at Baseline and 28–85 Years at Follow-up (Men = 420, Women = 232), Policy Research Centre Sport Leuven, 2002–2004 and 2012–2014

	Men					Women				
	Model 1		Model 2			Model 1		Model 2		
	β	R^2	β	B	SE	β	R^2	β	B	SE
RCS Waist circumference (cm) – RCS Total cholesterol (mg/dl)	0.164**	2.7%	0.195**	0.190	0.068	0.184**	3.4%	0.194*	0.201	0.094
RCS Waist circumference (cm) – RCS HDL cholesterol (mg/dl)	–0.332***	11.0%	–0.256***	–0.120	0.053	–0.265***	7.0%	–0.208*	–0.285	0.120
RCS Waist circumference (cm) – RCS LDL cholesterol (mg/dl)	0.175***	3.1%	0.212**	0.215	0.071	0.278***	7.8%	0.299**	0.317	0.094
RCS Waist circumference (cm) – RCS Ratio total/HDL cholesterol	0.348***	12.1%	0.309***	0.355	0.076	0.383***	14.7%	0.308**	0.267	0.076
RCS Waist circumference (cm) – RCS Triglycerides (mg/dl)	0.243***	5.9%	0.153*	0.198	0.090	0.130	1.7%	0.001	0.001	0.087
RCS Body Mass Index (kg/m^2) – RCS Total cholesterol (mg/dl)	0.114*	1.3%	0.083	0.087	0.077	0.171*	2.9%	0.280**	0.275	0.088
RCS Body Mass Index (kg/m^2) – RCS HDL cholesterol (mg/dl)	–0.310***	9.6%	–0.234**	–0.205	0.060	–0.230***	5.3%	–0.182*	–0.236	0.115
RCS Body Mass Index (kg/m^2) – RCS LDL cholesterol (mg/dl)	0.131**	1.7%	0.095	0.103	0.080	0.249***	6.2%	0.357***	0.358	0.088
RCS Body Mass Index (kg/m^2) – RCS Ratio total/HDL cholesterol	0.309***	9.5%	0.230**	0.282	0.086	0.379***	14.4%	0.360***	0.296	0.071
RCS Body Mass Index (kg/m^2) – RCS Triglycerides (mg/dl)	0.197***	3.9%	0.079	0.108	0.101	0.154*	2.4%	0.089	0.082	0.082

* $P < .05$; ** $P < .01$; *** $P < .001$.

Abbreviations: RCS, residual change score.

Note. Model 1: unadjusted. Model 2: adjusted for age, residual change score smoking, residual change score energy intake, residual change score screen time, residual change score Physical Activity Level and residual change score VO_2peak. There were missing values in VO_2peak relative due to risk profile, while missing values in other variables were due to technical or organizational problems.

measure points and the integration of confounders. Also a complete blood lipid profile was determined, with 5 parameters (including ratio total/HDL cholesterol) instead of a less complete blood lipid profile commonly used in previous studies.

Conclusions

ANTP showed more and stronger longitudinal associations with blood lipids after adjustment for potential confounders compared with CRF. An increase in WC and in women also BMI was more strongly associated with a deteriorated blood lipid profile. Ratio total/HDL cholesterol, a strong mortality indicator, has been found to be the most influenced cardiovascular health parameter by the ANTP.

Acknowledgments

This research is accomplished by the Policy Research Centre Sport. The Policy Research Centre Sport is funded by the Flemish government. The authors are indebted to the participants of this study.

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