図1．重心動揺の指標と骨格筋量の関係（両足立位）

両足開眼

r=-0.25

総軌跡長 [cm]

骨格筋量 [kg]

両足閉眼

r=-0.47
p<0.05

総軌跡長 [cm]

骨格筋量 [kg]

両足開眼

r=-0.25

単位軌跡長 [cm/秒]

骨格筋量 [kg]

両足閉眼

r=-0.47
p<0.05

単位軌跡長 [cm/秒]

骨格筋量 [kg]

両足開眼

r=0.05

単位面積軌跡長 [1/cm]

骨格筋量 [kg]

両足閉眼

r=0.01

単位面積軌跡長 [1/cm]

骨格筋量 [kg]
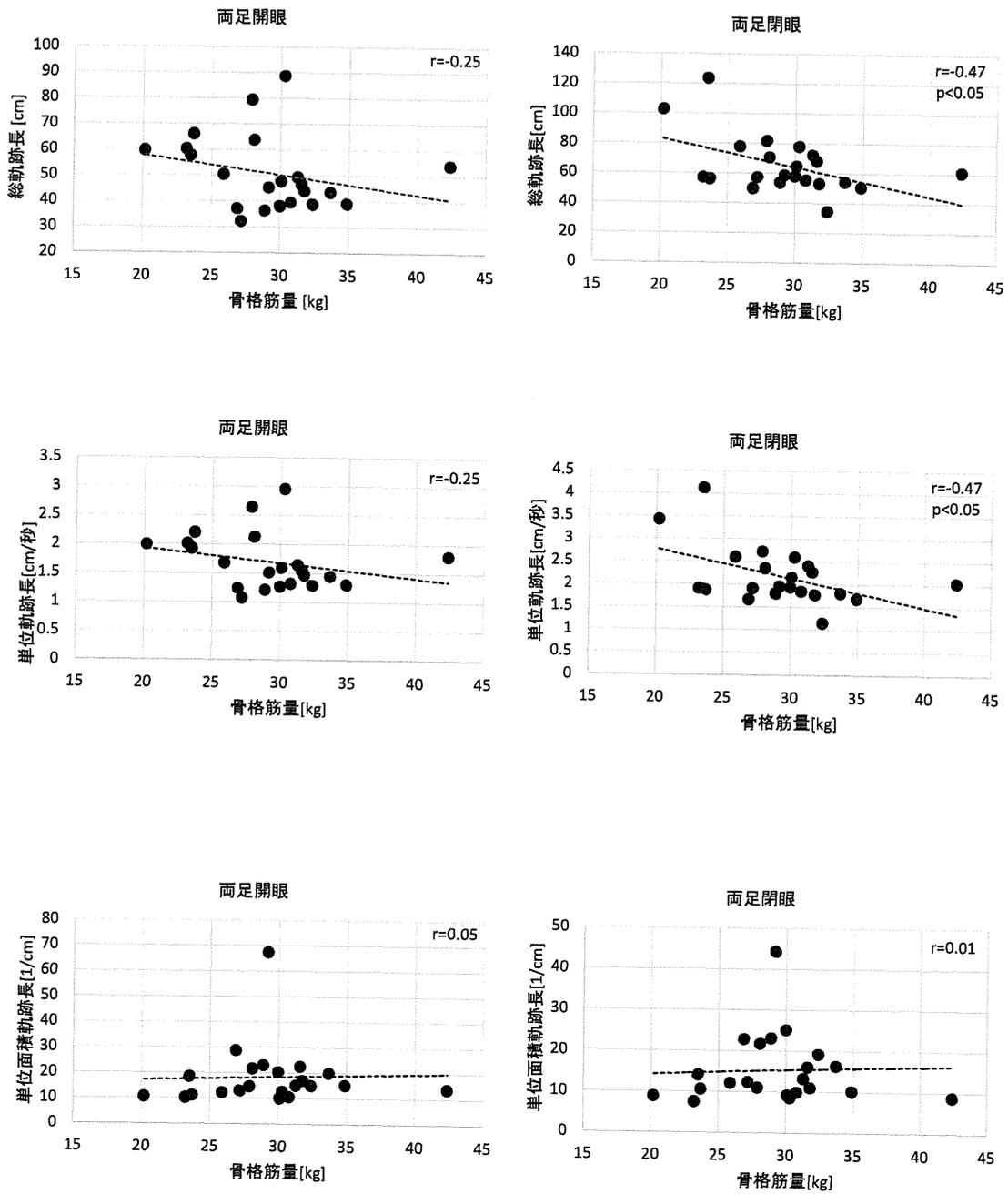
図2．重心動揺の指標と骨格筋量の関係（片足立位）

片足開眼

片足閉眼

片足開眼

片足閉眼

片足開眼
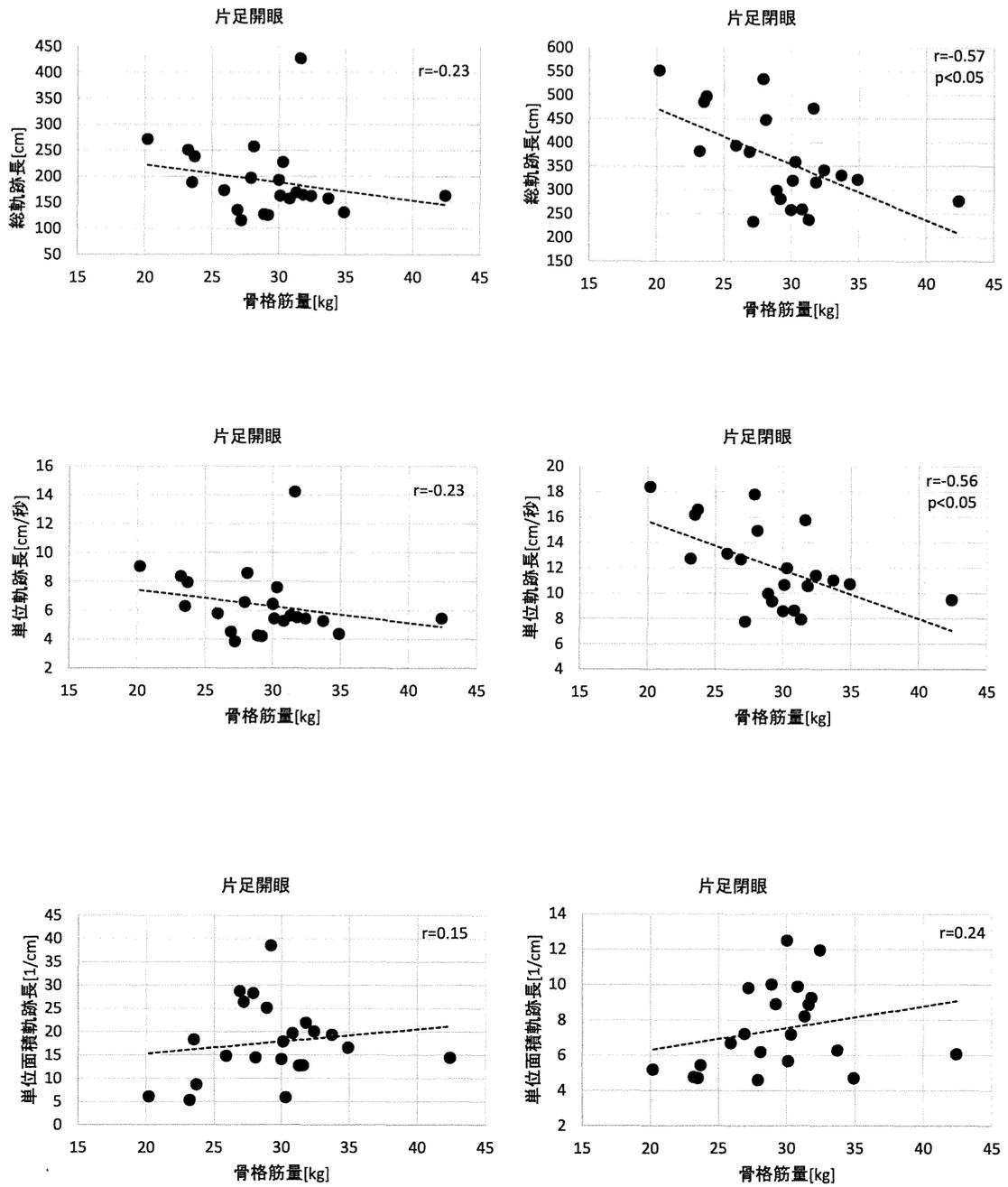
片足閉眼

図 3．重心動揺の指標と体脂肪率の関係（両足立位）
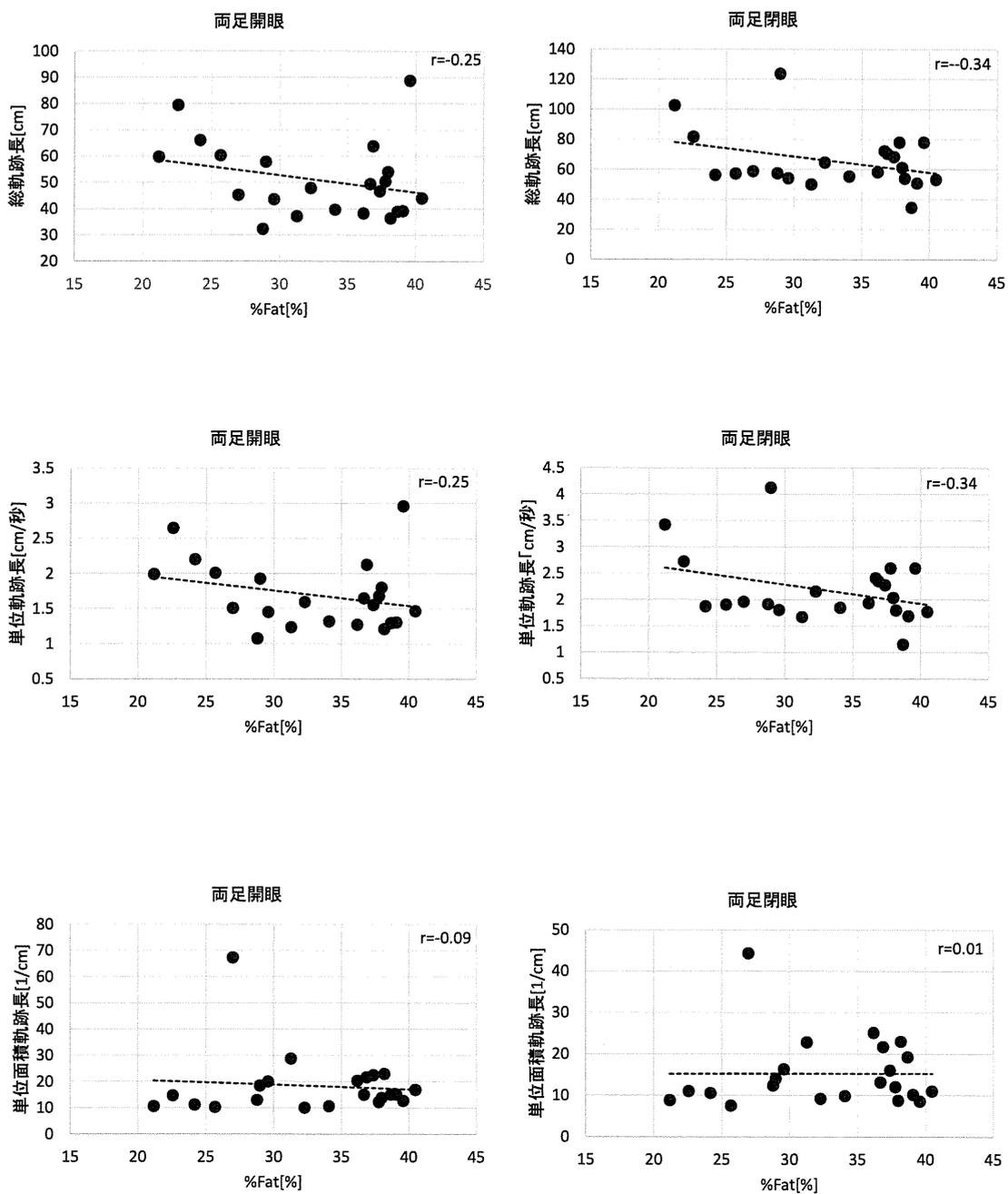
%Fat［％］：体脂肪率　％

図4. 重心動揺の指標と体脂肪率の関係（片足立位）

片足開眼

片足閉眼

片足開眼

片足閉眼

片足開眼
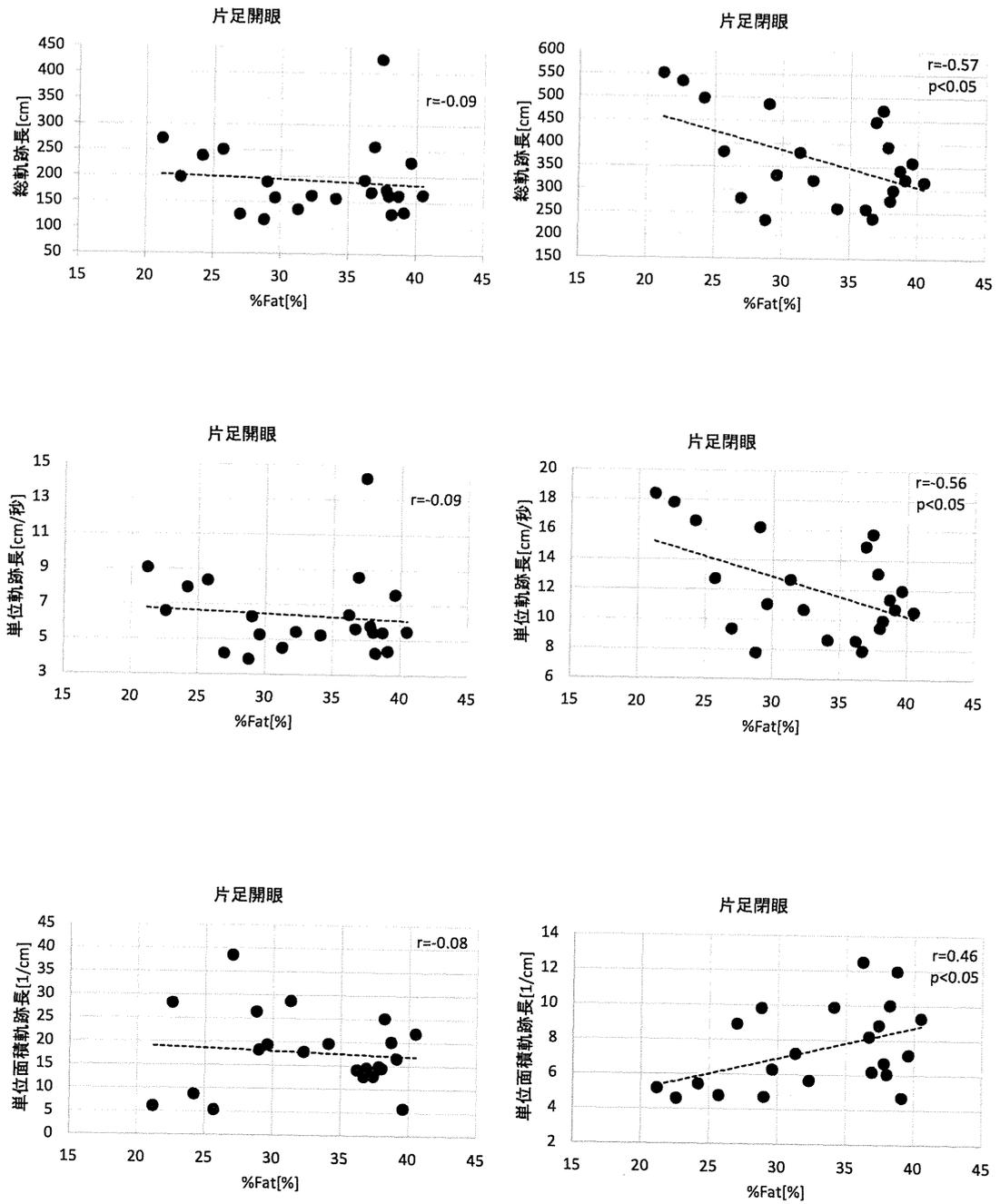
片足閉眼

%Fat［％］：体脂肪率　％

図5. 骨格筋量と単位面積軌跡長：介入前後の差（片足閉眼立位）

片足閉眼
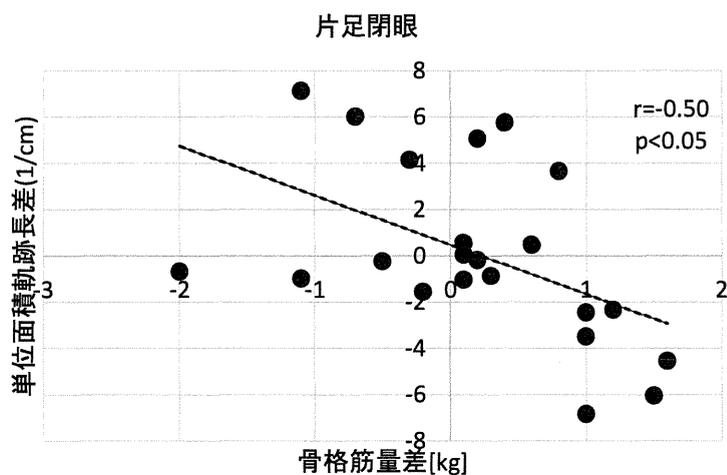
表1. 対象者の属性：男女別

	男 17名	女 5名	p値
身長 cm	140.8±10.1	141.4±10.3	0.91
体重 kg	46.4±10.9	48.1±9.6	0.76
身長SDS	0.4±1.2	0.8±1.2	0.56
肥満度 介入前 %	31.0±13.4	36.6±10.5	0.40
肥満度 介入後 %	31.4±12.4	32.2±12.5	0.90
BMI-SDS 介入前	1.6±0.3	1.9±0.2	0.04
BMI-SDS 介入後	1.6±0.3	1.8±0.3	0.30
腹囲 介入前 cm	77.7±9.9	77.9±5.6	0.96
腹囲 介入後 cm	78.6±10.6	75.7±5.5	0.57
内臓脂肪面積 介入前 cm2	53.3±16.7	35.0±19.1	0.08
内臓脂肪面積 介入後 cm2	53.8±17.8	45.1±27.5	0.41
皮下脂肪面積 介入前 cm2	170.3±35.5	177.4±45.7	0.75
皮下脂肪面積 介入後 cm2	165.3±48.0	160.7±52.9	0.86
体脂肪率 介入前 %	32.4±6.4	34.7±5.0	0.47
体脂肪率 介入後 %	34.6±6.1	35.9±6.3	0.68
筋肉量 介入前 kg	29.2±4.8	29.4±4.9	0.96
筋肉量 介入後 kg	29.6±4.7	29.1±4.6	0.85
休日歩数 介入中	8,980±2,113	7,684±3,648	0.32
平日視聴時間 介入中 min	150.7±53.6	89.9±58.3	0.04
休日視聴時間 介入中 min	205.9±62.3	144.9±83.8	0.09

表2. 重心動揺の指標と各種身体属性の相関

	両足					
	開眼			閉眼		
	総軌跡長 (cm)	単位軌跡長 (cm/秒)	単位面積軌跡長 (1/cm)	総軌跡長 (cm)	単位軌跡長 (cm/秒)	単位面積軌跡長 (1/cm)
身長	-0.23	-0.23	0.07	-0.47*	-0.47*	0.03
体重	-0.26	-0.26	-0.02	-0.45*	-0.45*	-0.02
身長SDS	0.33	0.33	-0.27	0.20	0.20	-0.45*
肥満度	-0.22	-0.22	-0.09	-0.20	-0.20	0.03
BMI-SDS	-0.06	-0.06	-0.32	-0.06	-0.06	-0.28
腹囲	-0.32	-0.32	0.08	-0.36	-0.36	0.11
内臓脂肪量	0.14	0.14	0.30	-0.22	-0.22	0.25
皮下脂肪量	0.01	0.01	-0.35	-0.04	-0.04	-0.28
体脂肪率	-0.27	-0.27	-0.09	-0.34	-0.34	0.00
筋肉量	-0.25	-0.25	0.05	-0.47*	-0.47*	0.01

	片足					
	開眼			閉眼		
	総軌跡長 (cm)	単位軌跡長 (cm/秒)	単位面積軌跡長 (1/cm)	総軌跡長 (cm)	単位軌跡長 (cm/秒)	単位面積軌跡長 (1/cm)
身長	-0.35	-0.35	0.16	-0.60*	-0.59*	0.17
体重	-0.19	-0.19	0.04	-0.57*	-0.56*	0.32
身長SDS	-0.20	-0.20	-0.06	0.11	0.12	-0.53*
肥満度	0.21	0.21	-0.10	-0.24	-0.25	0.53*
BMI-SDS	0.03	0.03	-0.14	-0.16	-0.16	0.20
腹囲	-0.02	-0.02	0.05	-0.52*	-0.51*	0.44*
内臓脂肪量	0.22	0.22	0.12	-0.04	-0.03	0.24
皮下脂肪量	0.10	0.10	-0.23	0.01	0.02	0.23
体脂肪率	-0.09	-0.09	-0.08	-0.50*	-0.50*	0.46*
筋肉量	-0.23	-0.23	0.15	-0.57*	-0.56*	0.24

*：p<0.05

表3．重心動揺と身体属性や生活習慣との相関：介入による変化

	両足					
	開眼			閉眼		
	総軌跡長 (cm)	単位軌跡長 (cm/秒)	単位面積軌跡長 (1/cm)	総軌跡長 (cm)	単位軌跡長 (cm/秒)	単位面積軌跡長 (1/cm)
肥満度介入前後差	0.04	0.04	−0.10	0.22	0.22	−0.03
BMI-SDS介入前後差	0.08	0.08	−0.08	0.18	0.18	−0.10
体脂肪率介入前後差	0.08	0.08	0.19	0.17	0.17	0.27
筋肉量介入前後差	0.01	0.01	−0.31	−0.13	−0.13	−0.45*
休日歩数	0.38	0.38	−0.12	−0.34	−0.34	−0.29
平日視聴時間	−0.15	−0.15	−0.04	0.09	0.09	−0.07
休日視聴時間	−0.05	−0.05	−0.25	0.05	0.05	−0.19

	片足					
	開眼			閉眼		
	総軌跡長 (cm)	単位軌跡長 (cm/秒)	単位面積軌跡長 (1/cm)	総軌跡長 (cm)	単位軌跡長 (cm/秒)	単位面積軌跡長 (1/cm)
肥満度介入前後差	−0.30	−0.29	0.02	−0.28	−0.38	0.06
BMI-SDS介入前後差	−0.39	−0.35	0.06	−0.32	−0.37	−0.05
体脂肪率介入前後差	−0.20	−0.27	−0.10	−0.12	−0.31	0.39
筋肉量介入前後差	0.12	0.19	−0.13	−0.07	0.07	−0.50*
休日歩数	0.11	−0.05	0.00	0.14	0.06	−0.16
平日視聴時間	−0.03	−0.02	−0.07	−0.14	−0.10	0.02
休日視聴時間	0.06	0.02	−0.10	−0.14	−0.11	0.13

＊：p<0.05

肥満小児における血清エイコサペンタエン酸アラキドン酸比（EPA/AA）と早期動脈硬化の関係について

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研究要旨

【目的】肥満小児の血中脂肪酸分析を行い、n3/n6 や EPA/AA と早期動脈硬化指標との関係を明らかにすること。【対象と方法】単純性肥満小児103名を対象に、身体計測、血圧測定、血液検査（糖代謝指標、血清脂質、全脂肪酸分析）を行った。うち31名に、頸動脈エコーを行い、EPA/AA と各種早期動脈硬化指標との相関について検討した。【結果】対象の平均年齢は11.2±2.7歳。平均肥満度は+44.6±18.5%。血中 EPA と AA の重量パーセントは各々、1.22±0.68、6.20±1.43、n3/n6 は0.16±0.55、EPA/AA は0.20±0.11 で、EPA や n3/n6、EPA/AA は低値であった。早期動脈硬化指標の Stiffnessβ は5.5±2.4 と比較的高く、n3/n6 や EPA/AA と Stiffnessβ の間に有意な負の相関が認められた（r=-0.38, P<0.05, r=-0.43, p<0.05）。【結論】肥満小児の EPA や n3/n6、EPA/AA は低値であり、n3/n6 や EPA/AA 低値と頸動脈硬化との間には相関が認められた。肥満小児の将来の心血管病発症予防には、EPA の豊富な青魚などの摂取を推奨する必要がある。

A. 研究目的

必須脂肪酸として知られている多価不飽和脂肪酸 (PUFA) には、エイコサペンタエン酸 (EPA) やドコサヘキサエン酸 (DHA) に代表される n-3 系 PUFA と、アラキドン酸 (AA) に代表される n-6 系 PUFA があり、n-3PUFA は動脈硬化を抑制し、n-6PUFA の過剰摂取は動脈硬化を促進するといわれている。成人では、高感度 CRP 高値例で EPA/AA が高いと心血管イベントのリスクが上昇するが、EPA 投与によって EPA/AA を上昇させればイベントの頻度が低下すると報告されている[1]。日本人は魚介類の消費量が多いといわれてきたが、最近は我が国の子ども達の魚離れが顕著であり、肥満小児はこの傾向が強い可能性がある。今回我々は、肥満小児の血清中 n3/n6 や EPA/AA レベルを明らかにし、n3/n6 や EPA/AA と早期動脈硬化指標との関係を検討する目的でこの研究を行った。

B. 研究方法

1. 対象

2008 から 2013 年に小児生活習慣病外来を受診した肥満小児103名（男児：63名、女児：40名）を対象とした。

2. 検査項目

1) 身体計測、血圧測定

身長、体重、腹囲を測定した。血圧は、自動血圧計を用い座位で3回測定した。身体計測値から、村田らの肥満度と腹囲身長比を計算した。

2) 血液生化学検査

空腹時採血で、血清脂質（TC, TG, HDLC）、糖代謝指標（FPG, IRI）、Adiponectin, Leptin、hs-CRP を測定した。更に、ガスクロマトグラフィー法を用いて、血清全脂肪酸分析（24種）を行った。

3) 早期動脈硬化の評価

31名に対して、血液検査と同日に総頸動脈エコー検査を行い早期動脈硬化指標を評価した。

総頸動脈エコー検査：右総頸動脈の分岐部の中枢側で内中膜複合体厚 (IMT) やStiffnessβを評価した。

3.統計学的検討

統計学的検討には、Stat View 5.0J を用い、相関関係の検討にはPeason の相関係数を用い、p<0.05 を有意とした。

（倫理面への配慮）

当研究は、事前に患児と保護者に血液検査の必要性や早期動脈硬化の評価法について十分説明し、承諾が得られた者のみに実施した。データの取り扱いは、個人情報の漏洩がない様に匿名化を行った。

C. 研究結果

対象の平均年齢は11.2±2.7歳。平均肥満度は+44.6±18.5%であった。腹囲身長比は男児が高値 (0.60±0.06 vs 0.57±0.04)、Leptin は女児が高値 (16.7±9.1 vs 25.4±12.9) であったが、その他の身体計測指標、血圧、生化学指標やAdiponectin, hsCRP には性差はなかった (表1.2)。対象の血中脂肪酸の重量パーセントには性差は認められず、EPA は1.2±0.7、n3/n6 は0.16±0.05、EPA/AA は0.20±0.11 と非常に低値であった (表3)。対象の各種早期動脈硬化指標にも性差は認められず、Mean IMT は0.44±0.05, Stiffnessβ は5.5±2.4 で、Stiffnessβ はやや高値であった。血清脂肪酸の重量%と各種早期動脈硬化指標との相関は、Stiffnessβ と n3/n6 や EPA/AA との間に有意の負の相関が認められた (図)。

D. 考察

心血管病や2型糖尿病などの発症には食生活や運動習慣などの生活習慣が強く関与している。我が国の虚血性心疾患の頻度が欧米より少ないのは、日本人は魚介類を多く摂取しているからだと考えられてきたが、最近の日本人の魚食離れは顕著で、日本人1人当たりの魚介類の摂取量は減少の一途を辿り、

平成18 年には肉類の摂取量に凌駕される状況に陥っている[2]。そしてこの傾向は小児や若年ほど著しい。

脂肪酸は、飽和脂肪酸 (SFA) と不飽和脂肪酸 (USFA) に大別され、不飽和脂肪酸は更に、一価不飽和脂肪酸 (MUFA) と多価不飽和脂肪酸 (PUFA) に分けられる。PUFA は最初の二重結合の位置によって更にn-3 系と n-6 系に分けられ、これらの量とバランスは動脈硬化の進展や心血管病発症に深く関係している。n-3 系 PUFA や n-6 系 PUFA は、生体内で合成できず、食物として取り込む必要がある必須脂肪酸であり、血清中や赤血球膜中の PUFA の量は摂取した食物の種類や内容によって大きく変動する。青魚に豊富に含まれる DHA や EPA は代表的なn-3PUFA であり、それらのn-3PUFA には、血清脂質の改善効果、抗炎症作用、血管保護作用、糖代謝改善作用、抗不整脈作用等様々な生理学的作用が知られている[3]。この様な背景から、近年の日本人の食生活の変化は、動脈硬化性疾患や2 型糖尿病の増加と関連している可能性がある。

従来、脂肪酸組成が慢性炎症に及ぼす指標として赤血球膜の n3/n6 が用いられてきた。しかし、赤血球膜の脂肪酸分析は現時点では健康保険適用外であるため、日常臨床に用いる事ができない。このため、最近血清中の EPA/AA が注目されている。血清中の脂肪酸の値は採血直前に摂取した食事の影響を強く受けるため、結果の解釈には注意を要するといわれてきたが、Yanagisawa らは、日本人の健診データを用いた検討によって、血中 EPA/AA と赤血球膜中のEPA/AA は非常に強い正相関 (r=0.91, p<0.0001) が認められたと報告しており[4]、血清中の EPA/AA 比は食生活の歪みに起因した、慢性炎症惹起性の脂肪酸バランスの乱れを反映している可能性がある。

我々は、単純性肥満小児を対象として血清中のn3/n6 や EPA/AA を検討した。その結果n3/n6 は0.16±0.05、EPA/AA は0.20±0.11 と低いことが明らかになった。n3/n6 や EPA/AA は食習慣を反映するため、年齢によって大きく値が異なる。魚食を好む傾向がある高齢者では高く、肉や植物性油脂を摂取する機会が多い若年者では低値である。35 歳未満の日本人

若年成人の血清n3/n6の平均値が0.67±0.25であることを考慮すると [4]、今回対象とした肥満小児のn3/n6は極めて低値であった。

我々は、総頸動脈エコー検査を用いて肥満小児と非肥満小児の早期動脈硬化指標を比較し、肥満小児の総頸動脈には既に Stiffness の亢進が認められる事を報告した [5]。今回、血液検査と同日に総頸動脈エコーを行った31例に対して、血清脂肪酸と早期動脈硬化指標との相関について検討したところ、n3/n6 やEPA/AA と Stiffnessβ に有意の負の相関が認められた。小児肥満診療のクリニカルアウトカムは動脈硬化性疾患や2型糖尿病発症の予防であり、今回の検討結果から、魚を主菜とした和食の推奨などの食事内容の指導によって、肥満小児に認められる早期動脈硬化への介入の可能性が示唆された。

E. 結論

肥満小児の血清 n3/n6 や EPA/AA は低値であり、魚離れと肉や植物性油脂の過剰摂取の存在が疑われた。血清 n3/n6 や EPA/AA や頸動脈 Stiffnessβ との間に負の相関が認められた。肥満に伴う早期動脈硬化予防には青魚等の n3PUFA を多く含む食事の推奨が望まれる。

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表1. 対象の身体的特徴

	男　性 (n=63)	女　性 (n=40)	全　体 (n=103)	最小 / 最大	p-value
年　齢 (歳)	11.2 ± 2.7	11.0 ± 2.8	11.2 ± 2.7	6 / 18	ns
身　長 (cm)	150.4 ± 13.8	149.3 ± 12.6	149.9 ± 13.3	117.8 / 175.7	ns
体　重 (kg)	62.1± 19.6	60.6 ± 18.5	61.5 ± 19.1	30.2 / 132.3	ns
肥満度 (%)	+45.3 ± 20.6	+43.4 ± 14.6	+44.6 ± 18.5	+20.8 / +131.7	ns
腹　囲 (cm)	89.9 ± 12.3	85.3 ± 11.0	88.1 ± 12.0	65.0 / 131.2	ns
腹囲身長比	0.60 ± 0.06	0.57 ± 0.04	0.59 ± 0.05	0.50 / 0.77	0.01
体脂肪率 (%)	32.9 ± 7.1	36.0 ± 8.6	34.1 ± 7.8	21.7 / 54.9	ns
収縮期血圧 (mmHg)	107.9 ± 11.3	104.8 ± 10.6	106.7 ± 11.1	84.0 / 140.0	ns
拡張期血圧 (mmHg)	61.0 ± 8.2	61.2 ± 8.3	61.1 ± 8.6	41.0 / 79.0	ns

平均値±標準偏差

表2. 対象の血液生化学検査結果と動脈硬化危険因子の集積数

	男　性 (n=63)	女　性 (n=40)	全　体 (n=103)	最小 / 最大	p-value
TC (mg/dl)	167.9 ± 25.3	172.1 ± 20.6	169.5 ± 23.5	113.0 / 232.0	ns
TG (mg/dl)	118.4 ± 66.8	110.43 ± 51.1	115.3 ± 61.1	24.0 / 367.0	ns
HDLC (mg/dl)	50.4 ± 11.8	48.5 ± 9.0	49.7 ± 10.8	29.0 / 82.0	ns
FPG (mg/dl)	92.3 ± 7.2	92.4 ± 7.0	92.3 ± 7.1	71.0 / 115.0	ns
IRI (μU/L)	15.3 ± 8.4	17.1 ± 8.6	16.0 ± 8.5	3.2 / 41.0	ns
HOMA-R	3.6 ± 2.2	4.0 ± 2.2	3.7 ± 2.2	0.8 / 11.6	ns
Adiponectin （μg/ml）	6.3 ± 2.0	6.7 ± 2.5	6.5 ± 2.2	1.9 / 13.1	ns
Leptin (ng/ml)	16.71 ± 9.1	25.4 ± 12.9	20.1 ± 11.5	3.3 / 75.0	0.0001
hs-CRP (mg/dl)	0.14 ± 0.19	0.10 ± 0.14	0.13 ± 0.18	0.01 / 1.14	ns
危険因子 （個）	1.8 ± 0.7	1.8 ± 0.7	1.8 ± 0.7	1 / 4	ns

平均値±標準偏差

表3. 対象の血清中各種脂肪酸の重量%

	男　性 (n=63)	女　性 (n=40)	全　体 (n=103)	最小 / 最大	p-value
SFAs	30.6 ± 1.9	30.7 ± 1.8	30.7 ± 1.9	27.2 / 36.0	ns
MFAs	23.7 ± 3.0	22.7 ± 2.5	23.3 ± 2.8	18.0 / 30.4	ns
n-3 PUFAs	5.6 ± 1.7	5.9 ± 1.5	5.7 ± 1.6	2.2 / 11.2	ns
n-6 PUFAs	35.2 ± 4.1	36.0 ± 3.5	35.5 ± 3.9	23.6 / 42.0	ns
n-3 / n-6	0.16 ± 0.06	0.17 ± 0.05	0.16 ± 0.05	0.06 / 0.32	ns
アラキドン酸 (AA)	6.4 ± 1.4	5.9 ± 1.5	6.2 ± 1.4	3.2 / 9.8	ns
エイコサペンタエン酸(EPA)	1.2 ± 0.8	1.3 ± 0.6	1.2 ± 0.7	0.2 / 3.9	ns
ドコサヘキサエン酸 (DHA)	3.9 ± 1.1	3.9 ± 1.0	3.8 ± 1.1	1.2 / 6.7	ns
EPA / AA	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.11	0.04 / 0.60	ns

＊従来推奨されてきた望ましい脂肪酸比率　S:M:P = 3:4:3,　n3PUFA:n6PUFA = 1 : 4（成人）
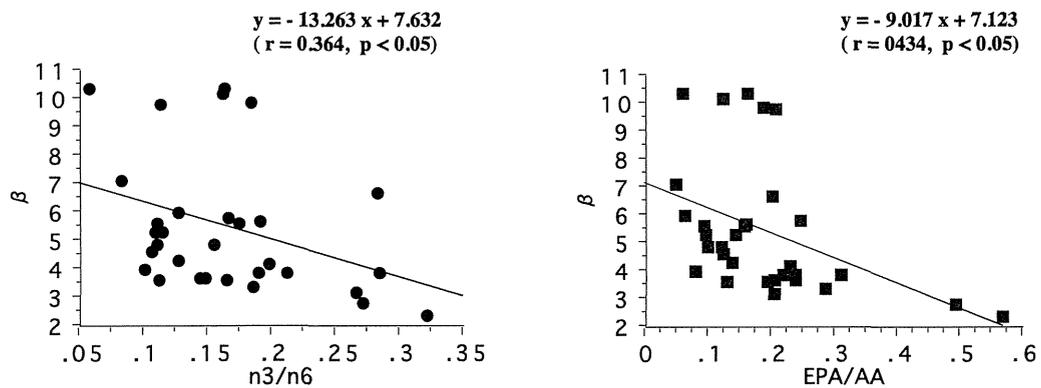＊成人では EPA/AA が0.29未満の低値群は EPA/AA が0.59の高値群と比較して心血管病イベントリスクが 3.84倍　　　　平均値±標準偏差

$$y = - 13.263 x + 7.632$$
$$(r = 0.364, p < 0.05)$$

$$y = - 9.017 x + 7.123$$
$$(r = 0434, p < 0.05)$$

図　n3/n6 や EPA/AA と総頸動脈 Stiffness βとの相関

研究成果の刊行に関する一覧表

書籍

著者氏名	論文タイトル名	書籍全体の編集者名	書　籍　名	出版社名	出版地	出版年	ページ
Yoshinaga M, Miyazaki A, Shinomiya M, Aoki M, Hamajima T, Nagashima M.	Impact of Sex and Lifestyle of Adolescents and Their Parents on Obesity	Watson RR	Nutrition in the Prevention and Treatment of Abdominal Obesity	Academic Press	London	2014	207-215

雑誌

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Lin L, Horigome H, Kato Y, Kikuchi T, Nakahara S, Sumazaki R.	Significant associations between hemostatic/fibrinolytic systems and assumulation of cardiovascular risk factors in Japanese ekementare schoolchildren.	Blood Coagul Fibrinolysis.	26 (1)	75-80	2015
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Impact of Sex and Lifestyle of Adolescents and Their Parents on Obesity

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INTRODUCTION

The prevalence of overweight or obese children has increased since the late twentieth century in most industrialized countries [1]. This prevalence doubled or trebled between the early 1970s and late 1990s in Australia, Brazil, Canada, Chile, Finland, France, Greece, Japan, the UK, and the USA [2]. However, recent data have shown that this increase in childhood obesity might be declining [1].

Cross-sectional analysis has shown that the prevalence of obesity has gradually decreased since the early 2000s, with the highest prevalence in the late 1990s to early 2000s in Japan [3]. Longitudinal studies have shown that the critical periods for developing obesity are in late infancy (between 5 and 6 years of age) and during the high school period in boys, and is mainly in late infancy in girls [3]. Another issue to be solved in Japan is the rapid increase in severe obesity in senior high school adolescents [4].

The development of cardiovascular disease (CVD) risk factors, including obesity, is associated with adverse behavioral patterns, such as decreased physical activity [5,6,8,9]; increased sedentary lifestyle, in particular television watching [5–10]; and unhealthy dietary habits [5,6,9]. Parental obesity is also strongly associated with CVD risk factors in children and adolescents [5,6,9].

Therefore, the present chapter aims to evaluate the effect of lifestyles of adolescents and their parents on the levels of CVD risk factors in adolescents based on data obtained from adolescent volunteers.

METHODS

Subjects

Two studies have been conducted in Japan. The first study was conducted from 2006 to 2008 and was announced through the local boards of education in three areas: Toyama, Chiba, and Kagoshima prefectures. The background of the first study has been described in detail elsewhere [9]. The study included 1358 healthy adolescent volunteers (587 males and 771 females), comprising senior high school students aged 15 to 18 years. All of the subjects gave written informed consent. The study consisted of a medical examination and a questionnaire. Volunteers were asked to complete the questionnaires before their medical examination. The questionnaire collected data on the lifestyles of both the subjects and their parents. Of the 1358 subjects, 54 participated in the study twice, and only data from the first visit were used. Of the remaining 1304 subjects, 549 did not complete the questionnaire and were excluded. Therefore, a total of 755 volunteers were included in the study (331 males and

424 females). Subjects of both sexes included in the study had lower mean levels of several CVD risk factors than those who were excluded (data not shown), suggesting that adolescent volunteers with more healthy lifestyles were more likely to completely answer the questionnaire. We obtained permission from the ethics committee of the National Hospital Organization Kagoshima Medical Center to use and analyze the data under the condition that the confidentiality would be maintained for all subjects.

The second study was conducted from 2012 onwards. The subjects in this study were children and adolescents in kindergartens, elementary schools, and junior high schools in Japan. This ongoing study was conducted in Kagoshima, Toyama, Fukuoka, and Aichi areas, and a total of 954 children and adolescents participated during 2012. Of these, 200 adolescents aged 12–15 years in junior high schools were the final subjects of the study. All subjects in the second study also gave written informed consent. The second study was done using the same methods as the first study. Volunteers were asked to complete questionnaires before their medical examination. All subjects in the second study completed the questionnaires.

Physical and Blood Biochemistry Parameters

Height was measured to the nearest 0.1 cm and weight was measured to the nearest 0.1 kg. Body mass index (BMI) was calculated as (weight in kg)/(height in m)^2. Blood pressure was measured three times using a TM-2571 automated oscillatory system (A&D Co. Ltd, Tokyo, Japan) after subjects had rested for 10 min in a seated position, and the mean value of the second and third measurements was used. Waist circumference was measured at the umbilical level to the nearest 0.1 cm.

Blood samples were collected the morning after an overnight fast. Levels of high-density lipoprotein (HDL) cholesterol were determined using a direct quantitative assay. Triglyceride and fasting plasma glucose (FPG) levels were measured using enzymatic assays and analyzed using a JCA-BM9030 automated analyzer (JEOL Ltd, Tokyo, Japan). Insulin levels were measured using a chemiluminescence immunologic assay and an automated Lumipulse PrestoII analyzer (Fujirebio Inc., Tokyo, Japan). All assays were performed by SRL Inc, Tokyo, Japan). The homeostasis model assessment of insulin resistance (HOMA-IR) was used as a surrogate marker for insulin resistance [11], and calculated as fasting insulin (in μU/mL) × fasting glucose (in mg/dL)/405.

Levels of adiponectin, leptin, and high-sensitivity C-reactive protein (hs-CRP) were measured at the same laboratory (SRL Inc). These adipocytokines and/or inflammatory markers are hereafter collectively referred to as biomarkers. Adiponectin was measured using the Human Adiponectin ELISA kit (Otsuka Pharmaceutical Inc, Tokyo, Japan), leptin measurement was done using the Human Leptin RIA KIT (Linco Research Inc, St. Charles, MO, USA), and hs-CRP was measured using the N-Latex CRP II (Dade Behring Inc, Marburg, Germany).

Definition of Cardiovascular Disease Risk Factors, Metabolic Syndrome, and Obesity

Abdominal obesity, hypertension, elevated triglyceride levels, decreased HDL cholesterol levels, and hyperglycemia were used as CVD risk factors in the present study. The definition of CVD risk factors was based on that of the International Diabetes Federation for the ages of 10–16 years as follows [12]: triglycerides, $\geq$150 mg/dL; HDL cholesterol, <40 mg/dL; blood pressure, $\geq$130 mmHg systolic or $\geq$85 mmHg diastolic; and FPG, $\geq$100 mg/dL. Preliminary 90th percentile values in male and female junior high school adolescents for waist circumference were $\geq$80 cm and $\geq$75 cm, respectively, based on data from the participants of the present study. The definition of CVD risk factors for ages >16 years was based on that for adults as follows [13]: triglycerides, $\geq$150 mg/dL; HDL cholesterol, <40 mg/dL in males and <50 mg/dL in females; blood pressure, $\geq$130 mmHg systolic or $\geq$85 mmHg diastolic; and FPG, $\geq$100 mg/dL. Preliminary 90th percentile values in male and female high school adolescents for waist circumference were $\geq$80 cm based on data from the participants of the present study. The definition of metabolic syndrome was based on that of the International Diabetes Federation [12,13].

The Examination Committee of Criteria for Obesity Disease in Japan recommended a BMI $\geq$25 kg/m^2 as the definition of obesity in the adult Japanese population [14]. Therefore, adolescent obesity in the present study was defined using the age- and sex-specific International Obesity Task Force standard corresponding to a BMI cutoff of 25 kg/m^2 at the age of 18 years [15].

Assessment of the Lifestyles of Adolescents and Their Parents

Self-reported lifestyle parameters for all subjects included regular times of going to bed and waking up; participation in school-based extracurricular (EC) physical activities; time spent in exercise, including walking, jogging, cycling, and EC physical activities on weekdays and holidays; time spent watching a screen, including watching television, non-school-related computer use, and games on weekdays and holidays; and score for eating breakfast (1, seldom; 2, occasional; 3, regular). Age, height, weight, and the following lifestyle information for both parents were also recorded: regular times for going to bed and waking up; time spent taking exercise,

TABLE 20.1 Characteristics of Adolescents[a,b]

Characteristic	Junior High School Adolescents			Senior High School Adolescents		
	Males	Females	P value	Males	Females	P value
Number	99	101	–	337	442	–
Age (years)	14.0 (0.9)	14.0 (1.0)	0.88	16.5 (0.8)[***]	16.7 (0.9)[***]	0.01
Height (cm)	162.5 (8.4)	155.7 (5.5)	<0.001	170.5 (6.1)[***]	158.3 (5.3)[***]	<0.001
Weight (kg)	50.9 (10.7)	47.4 (6.7)	0.006	60.8 (10.3)[***]	51.1 (6.5)[***]	<0.001
Body mass index (kg/m²)	19.1 (2.8)	19.5 (2.4)	0.32	20.9 (3.1)[***]	20.4 (2.3)[***]	0.01
Waist circumference (cm)	68.0 (8.1)	68.1 (6.5)	0.89	72.3 (8.2)[***]	71.2 (5.9)[***]	0.03
Systolic BP (mmHg)	106 (9)	100 (9)	<0.001	116 (10)[***]	106 (10)[***]	<0.001
Diastolic BP (mmHg)	58 (8)	56 (7)	0.02	63 (9)[***]	62 (9)[***]	0.02
Total cholesterol (mg/dL)	161 (23)	170 (30)	0.03	161 (28)	174 (27)	<0.001
LDL cholesterol (mg/dL)	89 (20)	97 (26)	0.02	89 (24)	96 (23)	<0.001
HDL cholesterol (mg/dL)	61 (12)	61 (11)	0.95	59 (12)	65 (13)[**]	<0.001
Triglycerides (mg/dL)	54 (39, 79)	63 (46, 84)	0.13	53 (41, 74)	52 (39, 69)[***]	0.23
FPG (mg/dL)	87 (6)	85 (5)	0.004	88 (7)	86 (6)	<0.001
Insulin (μU/mL)	7.2 (5.3, 10.7)	87 (5.7, 11.2)	0.07	6.4 (4.3, 9.1)[*]	7.0 (5.1, 9.5)[**]	0.07
HOMA-IR	1.6 (1.1, 2.3)	1.8 (1.2, 2.5)	0.16	1.4 (0.9, 2.0)	1.5 (1.1, 2.1)[**]	0.26
No of CV risks	0.2 (0.4)	0.2 (0.4)	0.65	0.7 (0.9)[**]	0.6 (0.8)	0.11
Adiponectin (μg/mL)	10.0 (4.1)	9.9 (4.6)	0.89	10.5 (4.0)	12.0 (4.6)[***]	<0.001
Leptin (ng/mL)	2.3 (1.8, 4.3)	7.9 (5.7, 12.8)	<0.001	1.1 (0.8, 2.2)[***]	6.2 (4.2, 8.6)[***]	<0.001
Hs-CRP (ng/mL)	82 (52, 177)	69 (25, 147)	0.053	111 (152, 268)[*]	58 (50, 137)[*]	<0.001
Birth weight (g)	3036 (533)	3014 (401)	0.74	3154 (425)[*]	3053 (407)	<0.001
Breast feeding (mo)	10.3 (4.3)	8.3 (4.9)	–	7.3 (5.5)[***]	7.8 (5.2)	0.29
Lifestyle factor						
EC activities (%)	73	47	<0.001	62	35	<0.001
Exercise (w, m)	90 (58, 120)	60 (30, 120)	0.16	120 (35, 150)	40 (10, 120)	<0.001
Exercise (h, m)	120 (30, 218)	60 (0, 180)	0.006	120 (30, 210)	30 (0, 120)	<0.001
Exercise (av, m)	90 (51, 150)	73 (25, 137)	0.04	120 (39, 167)	40 (13, 129)	<0.001
Screen (w, m)	90 (60, 150)	90 (60, 120)	0.46	120 (60, 180)	90 (60, 150)	0.70
Screen (h, m)	180 (120, 278)	180 (120, 240)	0.48	180 (120, 240)	180 (120, 240)	0.10
Screen (av, m)	118 (77, 177)	120 (77, 171)	0.92	120 (77, 184)	120 (69, 180)	0.21
Regular breakfast (%)	96%	93%	0.54	96%	92%	0.05

[a]Data are expressed as the mean (standard deviation). [b]Statistical analysis was performed for each sex between junior and high school adolescents; significance levels are shown as:[*]$P<0.05$. [**]$P<0.01$. [***]$P<0.001$.

Variables with highly skewed distribution (triglycerides, insulin, HOMA-IR, leptin, high-sensitive CRP, exercise time, and screen time) are expressed as the mean (95% confidence interval).BP, blood pressure; CVD, cardiovascular; EC activities, extracurricular physical activities; exercise, exercise time; FPG, fasting plasma glucose; HOMA-IR, homeostasis assessment of insulin resistance; hs-CRP, high-sensitivity C-reactive protein; LDL, low-density lipoprotein; screen, screen time; (w, m), (weekday, minutes); (h, m), (holiday, minutes); (av, m), (average value per day, minutes).

2. DIET, SUPPLEMENTS, AND FOODS IN THE MANAGEMENT OF VISCERAL OBESITY

TABLE 20.2 Characteristics of Parents[a]

Characteristics	Junior High School Adolescents		Senior High School Adolescents	
	Males	Females	Males	Females
Characteristics and lifestyle of fathers				
Age (years)	44.1 (5.4)	45.3 (6.7)	47.5 (4.6)	48.1 (5.2)
Body mass index (kg/m²)	24.0 (3.4)	23.8 (3.2)	23.7 (3.2)	23.5 (2.6)
Exercise (av, m)	14 (0, 43)	17 (0, 51)	10 (0, 39)	17 (0, 43)
Screen (av, m)	150 (93, 197)	150 (77, 214)	129 (77, 180)	137 (94, 206)
Having a regular breakfast (%)	76	69	80	81
Smoking rate (%)	39	40	42	42
Characteristics and lifestyle of mothers				
Age (years)	44.1 (5.4)	43.5 (5.2)	44.8 (3.7)	45.4 (4.1)
Body mass index (kg/m²)	24.0 (3.4)	22.3 (4.2)	21.7 (2.8)	21.7 (3.0)
Exercise (av, m)	0 (0, 21)	0 (0, 21)	9 (0, 30)*	15 (0, 30)[b]
Screen (av, m)	124 (75, 180)	120 (60, 184)	120 (77, 180)	137 (77, 194)
Having a regular breakfast (%)	90	89	89	89
Smoking rate (%)	6	8	11	8

[a]Data are expressed as the mean (standard deviation). [b]Mothers of male and female senior high school adolescents had a longer exercise time than those of junior high school adolescents.

Highly skewed variables in distribution (exercise time and television-watching time) were log-transformed before analysis to yield unimodal symmetry. These data are expressed as the median (interquartile ranges).Exercise (av, m), exercise time (average value per day, minute); screen (av, m), screen time (average value per day).

including walking, jogging, and cycling on weekdays and holidays; time spent watching a screen, including watching television and playing television- and/or computer-based games on weekdays and holidays; score for eating breakfast (1, seldom; 2, occasional; 3, regular); and history of smoking. Information on birth weight of the adolescents and duration of breastfeeding during infancy was obtained from the mothers.

Statistical Analysis

Data are expressed as the mean and standard deviation. Data for highly skewed variables in distribution are expressed as the median and interquartile range. Differences in mean values were examined using unpaired Student's t-tests. To determine the effect of lifestyles of adolescents and their parents on the levels of adolescent CVD risk factors, multivariate regression analyses were performed using each CVD risk level as a dependent variable, and the significant variables (P value <0.05) in previous simple regression analyses as independent variables. Highly skewed variables were log-transformed to yield unimodal symmetry, and these are indicated by ln(variable) hereafter to indicate the transformation. In regression analysis, dependent variables

included BMI, waist circumference, systolic blood pressure, HDL cholesterol, ln(triglycerides), ln(insulin), ln(HOMA-IR), the number of CVD risk factors, adiponectin, ln(leptin), and ln(hs-CRP). Independent variables include age, presence or absence of participation in EC physical activities, ln(exercise time), ln(screen time), presence or absence of a regular breakfast for adolescent volunteers, age, BMI, ln(exercise time), ln(screen time), and the presence or absence of smoking habits of parents. Statistical analysis was performed using IBM SPSS Statistics version 21.0 (Tokyo, Japan). Results with a two-sided P value <0.05 were considered to be significant.

RESULTS

Characteristics of Subjects

Sex differences were present in junior and senior high school adolescent volunteers. Sex differences in height, weight, systolic and diastolic blood pressure, total cholesterol, FPG, and leptin were found in junior high school adolescents. Sex differences in age, height, weight, BMI, waist circumference, systolic and diastolic blood pressures, total cholesterol, and HDL cholesterol, FPG, insulin, adiponectin, leptin, hs-CRP, and birth weight were

TABLE 20.3 Effect of Lifestyle on Cardiovascular Risk Factors in Junior High School Adolescents by Simple Regression Analysis

	BMI	WC	SBP	HDLc	ln(TG)a	FPG	ln (insulin)a	ln (HOMA-IR)a	No of risk factors	AN	ln(leptin)a	ln (hs-CRP)a
Males (n=99)												
Age	3.66***	3.99***	2.44*	-2.36*	2.09*	–	2.18*	2.15*	–	–	–	–
EC activities[b]	-4.34***	-4.69***	-3.14**	3.73***	-2.81**	–	-2.30*	-2.16*	-2.86**	–	-4.08***	–
ln(screen time)a	–	–	–	–	–	–	2.63*	2.46*	–	–	–	–
ln(paternal exercise time)a	–	–	–	–	–	–	–	–	–	2.31*	–	–
Maternal BMI	3.19**	3.89**	–	–	–	–	–	–	–	–	3.52***	–
Females (n=101)												
Age	2.09*	–	–	–	–	–	–	–	–	–	–	–
EC activities[b]	-2.86**	-2.95**	–	3.60***	-2.24*	–	–	–	–	–	-5.30***	–
ln(exercise time)a	-3.66***	-3.49***	-2.85**	3.16**	–	–	–	–	–	–	-3.80***	–
Paternal BMI	3.21**	3.27**	–	-2.26*	–	–	–	–	2.39*	–	2.40*	–
Maternal BMI	3.10**	4.04***	–	-2.07*	–	2.08*	–	–	3.33**	–	2.42*	–

*P<0.05. **P<0.01. ***P<0.001. aHighly skewed variables in distribution (levels of triglycerides, insulin, HOMA-IR, leptin, hs-CRP, exercise time, and screen time) were log-transformed before analysis to yield unimodal symmetry, which are indicated by ln(variable) to indicate the transformation. bAdolescents were asked whether they participated in EC activities (1, participated; 0, did not participate).

Values are expressed as t-values obtained by simple regression analysis. Data without significance were not included in the table. –, Variables that were not significant in simple or multivariate regression analyses. AN, adiponectin (in μg/mL); BMI, body mass index (in kg/m²); EC activities, extracurricular physical activities; exercise or screen time, average time spent (in min) per day for exercise or watching a screen; FPG, fasting plasma glucose (in mg/dL); HDLc, high-density lipoprotein cholesterol (in mg/dL); HOMA-IR, homeostasis model assessment of insulin resistance; hs-CRP, high-sensitivity C-reactive protein (in ng/mL); regular breakfast, regular breakfast consumption; SBP, systolic blood pressure (in mmHg); TG, triglycerides; WC, waist circumference.

found in senior high school adolescents (Table 20.1). Female adolescents showed a significantly lower rate of participation in EC physical activities and spent significantly less time on exercise than did male adolescents in junior and senior high school. In contrast, the amount of screen time was similar for both sexes (Table 20.1). No junior high school volunteers fulfilled the criteria of metabolic syndrome; four senior high school volunteers fulfilled the criteria.

Parental BMIs and time spent watching a screen were similar for both sexes (Table 20.2). Mothers of male and female senior high school adolescents participated in more exercise than did those of junior high school adolescents.

Effect of Lifestyle on Cardiovascular Disease Risk Factor Levels in Junior High School Adolescents

The effect of lifestyle on CVD risk factor levels determined by simple and multivariate regression analysis is shown in Tables 20.3 and 20.4. Multivariate regression analysis showed that the effect of adolescent lifestyle on BMI or waist circumference was different between sexes.

In male adolescents, BMI and waist circumference were associated with maternal BMI, but not with paternal BMI. Participation in EC physical activity greatly decreased with worsening BMI and waist circumference. In female adolescents, BMI and waist circumference were associated with paternal and maternal BMI. Participation in EC physical activity was widely associated with improved CVD risk factors, except for obesity, including lowering systolic blood pressure, increasing HDL cholesterol levels, decreasing the level of ln(triglycerides), and decreasing the accumulation of CVD risk factors.

Effect of Lifestyle on Cardiovascular Disease Risk Factor Levels in Senior High School Adolescents

The effect of lifestyle on CVD risk factor levels determined by simple and multivariate regression analysis is shown in Tables 20.5 and 20.6. Multivariate regression analysis showed that the effect of adolescent lifestyle on BMI or waist circumference was sex dependent and was different between junior and senior high school adolescents. In male adolescents, higher paternal and maternal BMI were independently associated with a high BMI and

TABLE 20.4   Effect of Lifestyle on Cardiovascular Risk Factors in Junior High School Adolescents by Multivariate Regression Analysis

	BMI	WC	SBP	HDLc	ln(TG)[a]	ln(insulin)[a]	ln (HOMA-IR)[a]	No of risks	AN	ln(leptin)[a]
Males (n=99)										
EC activities[b]	−3.09**	−3.40**	−2.4*	2.99**	−2.14*	−	−	−2.86**	−	−3.74***
ln(screen time)[a]	−	−	−	−	−	2.68**	2.51*	−	−	−
ln(paternal exercise time)[a]	−	−	−	−	−	−	−	−	2.31*	−
Maternal BMI	2.87**	3.64***	−	−	−	−	−	−	−	3.43***
Females (n=101)										
EC activities	−	−	−	−	−2.24*	−	−	−	−	−3.18**
ln(exercise time)[a]	−	−	−2.85**	−	−	−	−	−	−	−
Paternal BMI	3.08**	3.03**	−	−	−	−	−	2.48*	−	−
Maternal BMI	2.65**	3.92***	−	−	−	−	−	3.17**	−	2.29*

*$P<0.05$. **$P<0.01$. ***$P<0.001$. [a]Highly skewed variables in distribution (levels of triglycerides, insulin, HOMA-IR, leptin, hs-CRP, exercise time, and screen time) were log-transformed before analysis to yield unimodal symmetry, which are indicated by ln(variable) to indicate the transformation. [b]Adolescents were asked whether they participated in EC activities (1, participated; 0, did not participate).

Values in the table are expressed as the t-value by multivariate regression analysis. Data without significance were not included in the table.

greater waist circumference. Paternal BMI had a stronger effect on male adolescent BMI and waist circumference than did maternal BMI. Having a regular breakfast was associated with a lower BMI and smaller waist circumference. Conversely, higher maternal BMI, but not higher paternal BMI, was associated with a high BMI and greater waist circumference in female adolescents.

Participation in EC physical activity had a large effect on the following risk factors in male and female senior high school adolescents: levels of HDL cholesterol, ln(triglycerides), ln(insulin), ln(HOMA-IR), adiponectin, and ln(leptin) in both sexes; and systolic blood pressure and the total number of CVD risk factors in male senior high school adolescents. Time spent watching a screen was negatively associated with HDL cholesterol levels for both sexes. Additionally, a longer time spent watching a screen was associated with high levels of ln(triglycerides) and ln(leptin) and low levels of adiponectin in female senior high school adolescents.

Concerning the association between ln(screen time) and obesity in junior and senior high school adolescents, ln(screen time) was weakly associated with a higher waist circumference (abdominal obesity) only in female senior high school adolescents. Screen time of >120 min/day was not associated with the presence of obesity, as defined by international cut offs, or with the presence of abdominal obesity defined by increased waist circumference (data not shown).

Birth weight and duration of breastfeeding were not significant for either sex (data not shown).

DISCUSSION

The present study shows that participation in school-based EC physical activities and parental BMI are strongly associated with the levels of one or more CVD risk factors in adolescents. We also show sex differences and age-specific effects on adolescent BMI and waist circumference, indicating that strategies to prevent the development of CVD risk factors in adolescents should account for sex and age.

Physical activity, especially moderate-to-vigorous physical activity, is associated with beneficial metabolic profiles [8,16]. Participating in EC activities to experience sports or liberal arts are encouraged in junior and senior high schools in Japan. In the present study, multivariate regression analysis showed that participation in EC physical activities is highly associated with improving levels of CVD risk factors in male and female adolescents. Especially in male adolescents, participating in EC physical activities is associated with improvements in many CVD risk factors, such as abdominal obesity, hypertension, low HDL cholesterol levels, and high triglyceride levels in the junior high school period, and hypertension, low HDL cholesterol levels, high triglyceride levels, and insulin resistance in the senior high school period. In female senior high school adolescents, participating in EC activities is associated with improvements in levels of CVD risk factors. The United States Department of Health and Human Services has called for an expansion of school-based EC sports

2. DIET, SUPPLEMENTS, AND FOODS IN THE MANAGEMENT OF VISCERAL OBESITY

TABLE 20.5 Effect of Lifestyle on Cardiovascular Risk Factors in Senior High School Adolescents by Simple Regression Analysis

	BMI	WC	SBP	HDLc	ln(TG)[a]	FPG	ln (insulin)[a]	ln (HOMA-IR)[a]	No of risks	AN	ln (leptin)[a]	ln (hs-CRP)[a]
Males (n=337)												
Age	–	2.66**	–	–	–	–	–	–	–	–2.10*	–	–
EC activities[b]	–	–	–2.03*	5.29***	–4.49***	–	–3.61***	–4.50***	–4.51***	2.36*	–4.73***	–
ln(exercise time)[a]	–	–	–	3.66***	–3.67***	–	–	–3.34**	–	–	–2.68**	–
ln(screen time)[a]	–	–	2.80**	2.55**	–	–	2.27*	–	2.70**	–	2.13*	–
Regular breakfast[¶]	–2.70**	–3.07**	–	–	–	–	–	–2.21*	–	–	2.88**	–
Paternal BMI	5.32***	4.95***	–	–	–	–	2.55*	2.34*	–	–	3.29**	2.52*
ln(paternal exercise time)[a]	–	–	–	–	–2.16*	–	–	–	–	–	–	–
Maternal BMI	3.81***	3.29***	2.14*	–	–	–	–	–	–	2.18*	–	–
ln(maternal exercise time)[a]	–	–	2.41*	–	–	–	–	–	–	–	–	–
Females (n=442)												
Age	–	–	–3.25**	–	–	–	–	–	–	–	–	–
EC activities	–	–	–	6.23***	–3.58***	–	–4.25***	–4.17***	–	2.63**	–6.09***	2.48*
ln(exercise time)[a]	–	–	–	3.58***	–2.35*	–	–4.22***	–4.19***	–	–	–5.10***	2.28*
ln(screen time)[a]	2.33*	2.26*	–	–2.46*	2.11*	–	–	–	–	–2.55*	2.96**	–
Regular breakfast[¶]	–	–	–	–	–	–	–	–	–	–	–	–
Paternal BMI	2.08*	–	–	–	–	–	–	–	–	–	–	–
Maternal BMI	4.38***	3.03**	–	–	–	–	0.49	–	2.33*	–	–	–

*P<0.05. **P<0.01. ***P<0.001. [a]Highly skewed variables in distribution (levels of triglycerides, insulin, HOMA-IR, leptin, hs-CRP, exercise time, and screen time) were log-transformed before analysis to yield unimodal symmetry, which are indicated by ln(variable) to indicate the transformation. [b]Adolescents were asked whether they participated in EC activities (1, participated; 0, did not participate).[¶]Adolescents were asked whether they ate breakfast (1: seldom, 2: occasionally, or 3: regularly).

programs to address the obesity epidemic [16,17]. The present study reinforces the premise that participation in school-based EC physical activities has a considerable impact on the levels of multiple CVD risk factors in adolescents.

Concerning the effect of parental BMI on CVD risk factors in children and adolescents, previous studies have shown a greater influence of maternal BMI than paternal BMI on childhood adiposity [18–20]. Sun et al. reported that, based on data obtained in 2002, maternal obesity was more strongly associated with adolescent obesity than was paternal obesity in 2842 males and 2911 females aged 12–13 years in Japan [21]. From data obtained in 2001, Kazumi et al. reported that adolescent BMI was associated with maternal BMI, but not with paternal BMI, in 148 male adolescents aged 18 years in Japan [22]. The present data shows sex and age differences. In junior high school, BMI in male and female

adolescents was associated with maternal BMI, but paternal BMI was not associated with BMI in male adolescents. In senior high school, BMI in male adolescents was associated with paternal or maternal BMI. Importantly, paternal BMI was more strongly associated with BMI in male adolescents than was maternal BMI. BMI in female adolescents was associated with maternal BMI but not with paternal BMI. The reason for sex and age differences between adolescent and parental BMI should be further investigated to determine whether adolescent and/or parental attitudes have been changing. Nevertheless, these data suggest that approaches for adolescent obesity that focus on parents should consider the sex of the parent.

Screen time is well known as being associated with unfavorable body composition and CVD risk factors. In the present study, a longer screen time was not strongly associated with obesity. One reason for this low level of

2. DIET, SUPPLEMENTS, AND FOODS IN THE MANAGEMENT OF VISCERAL OBESITY