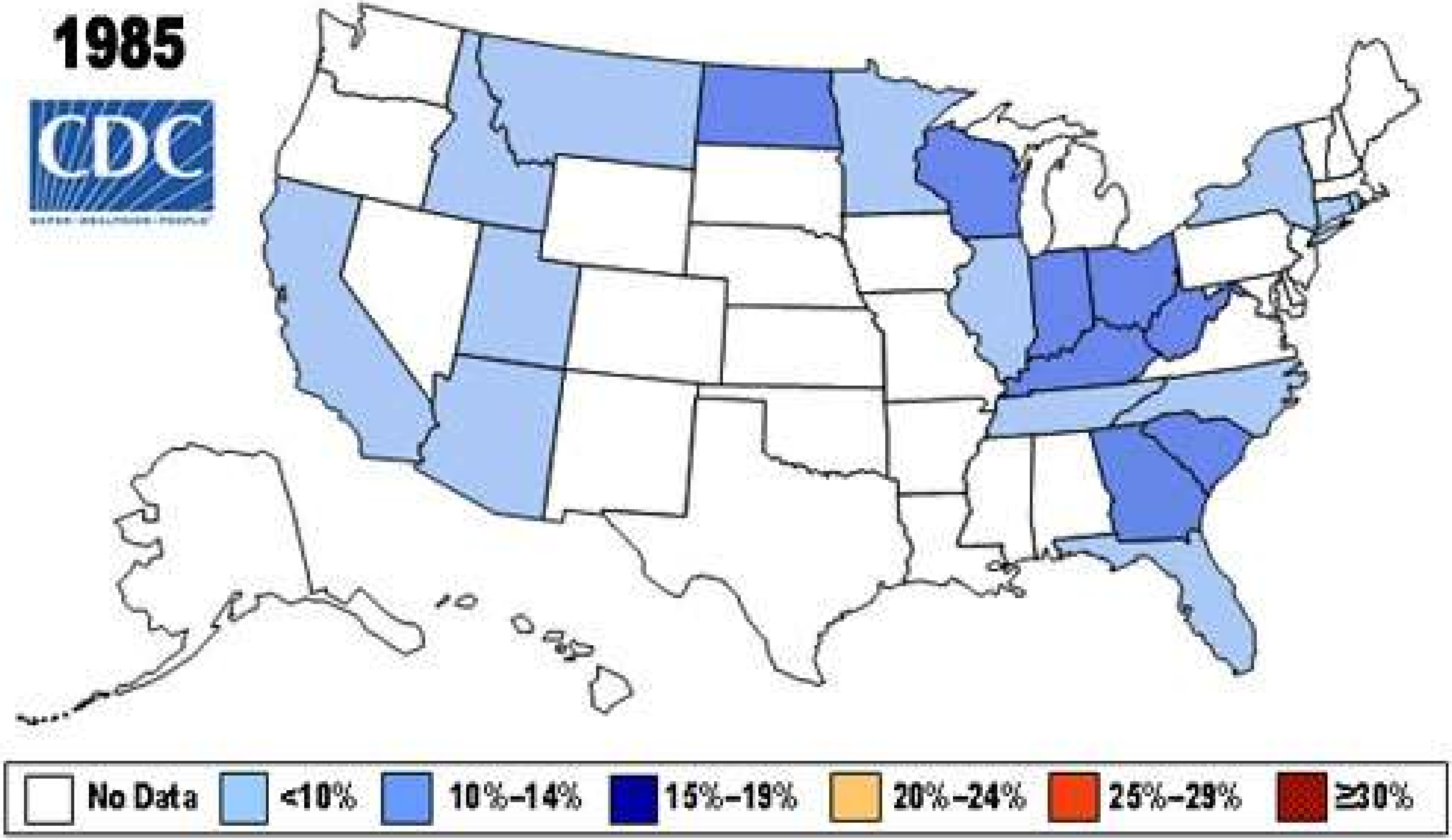
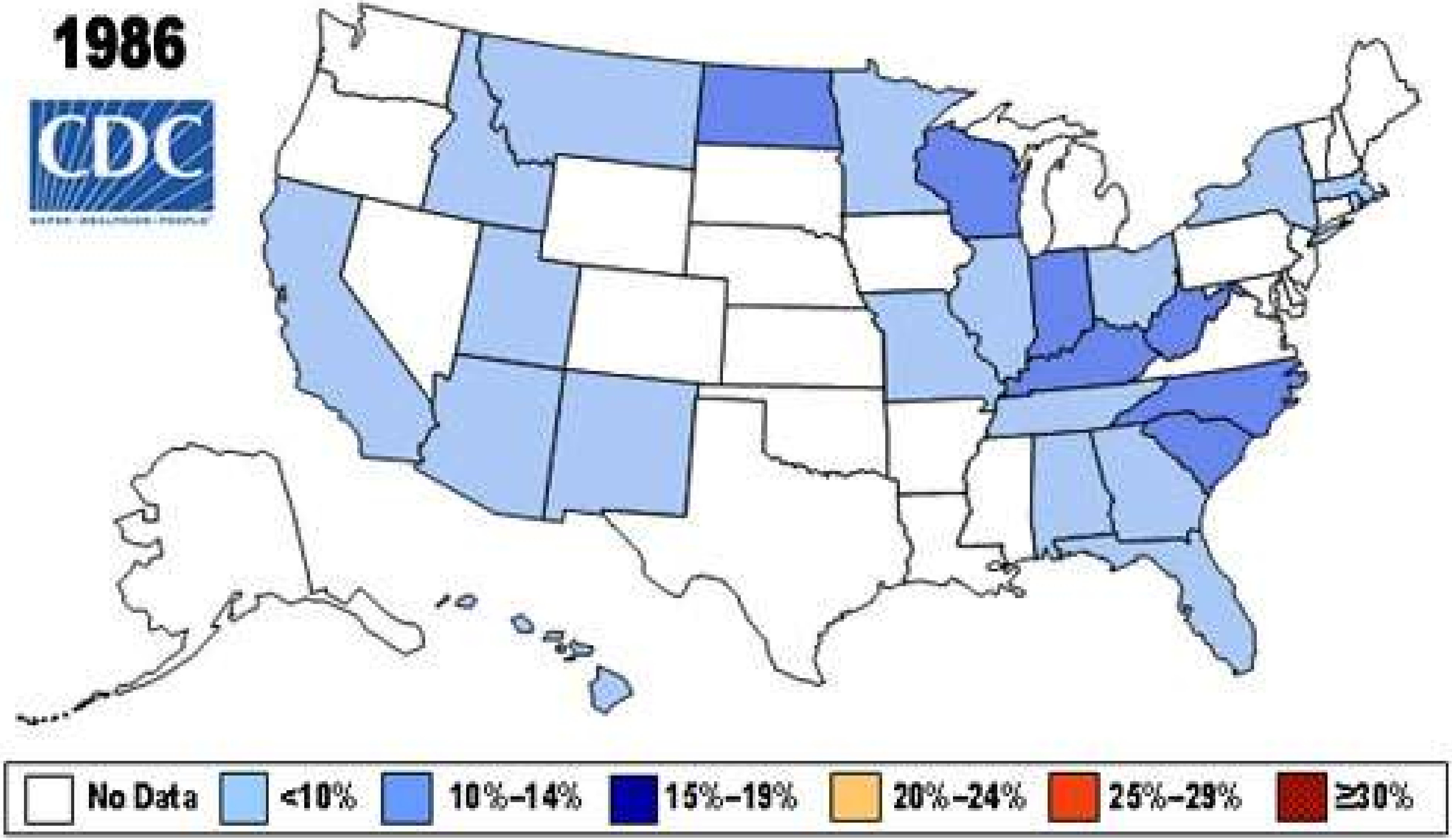
Fitness vs Fatness in controlling type 2 diabetes and metabolic disease risks

전용관 교수
연세대학교 스포츠레저학과

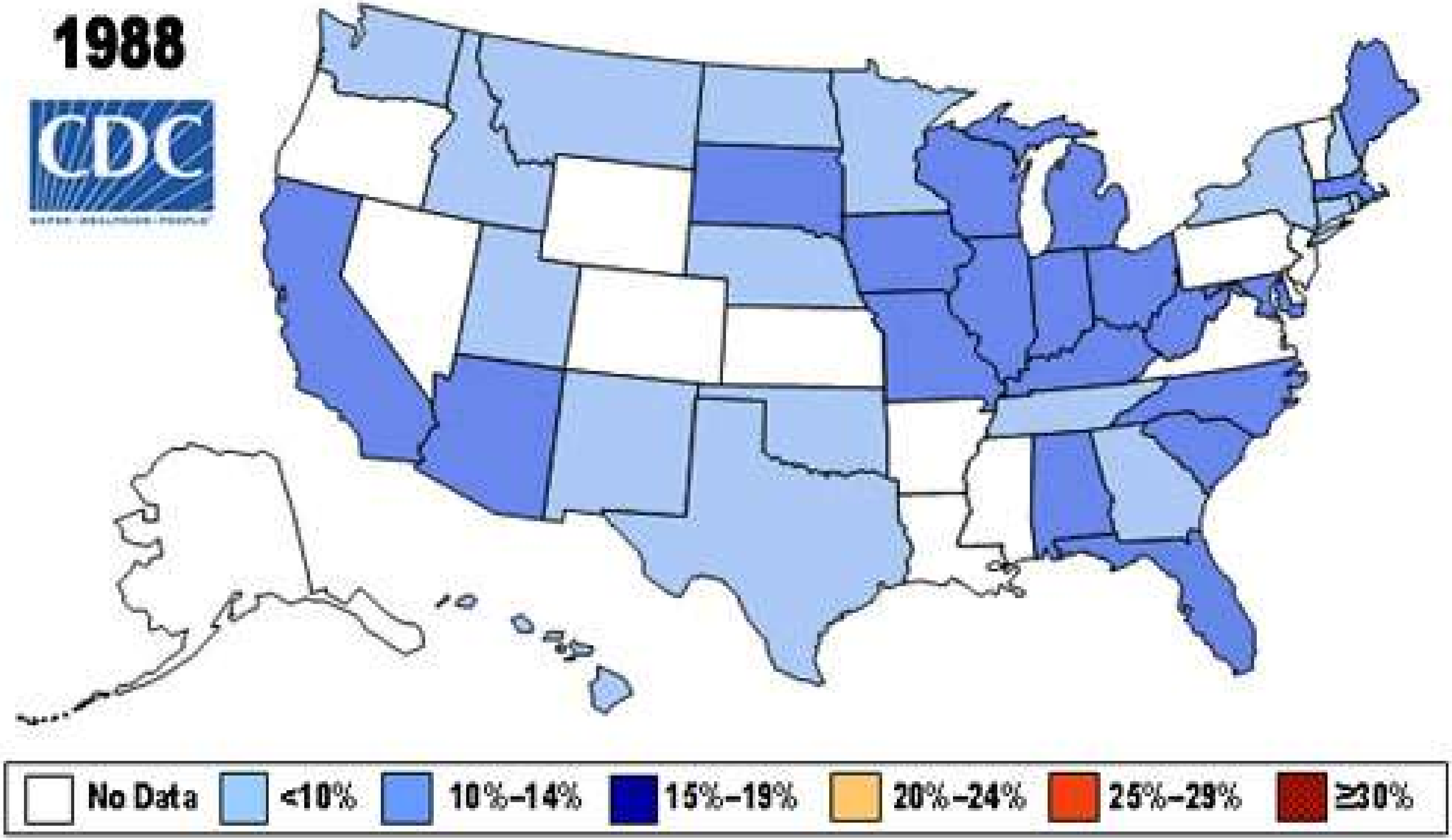
1985



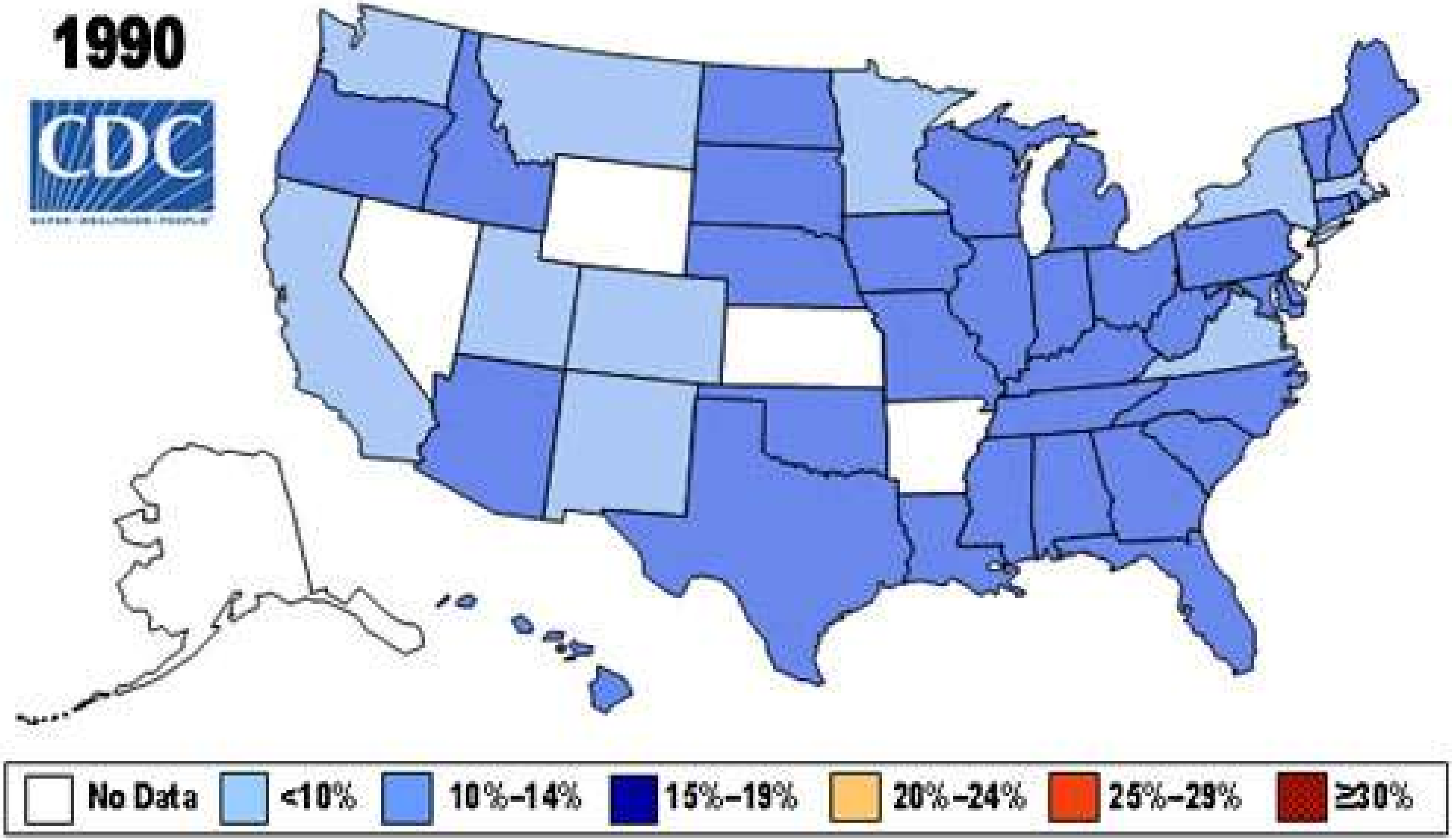
1986

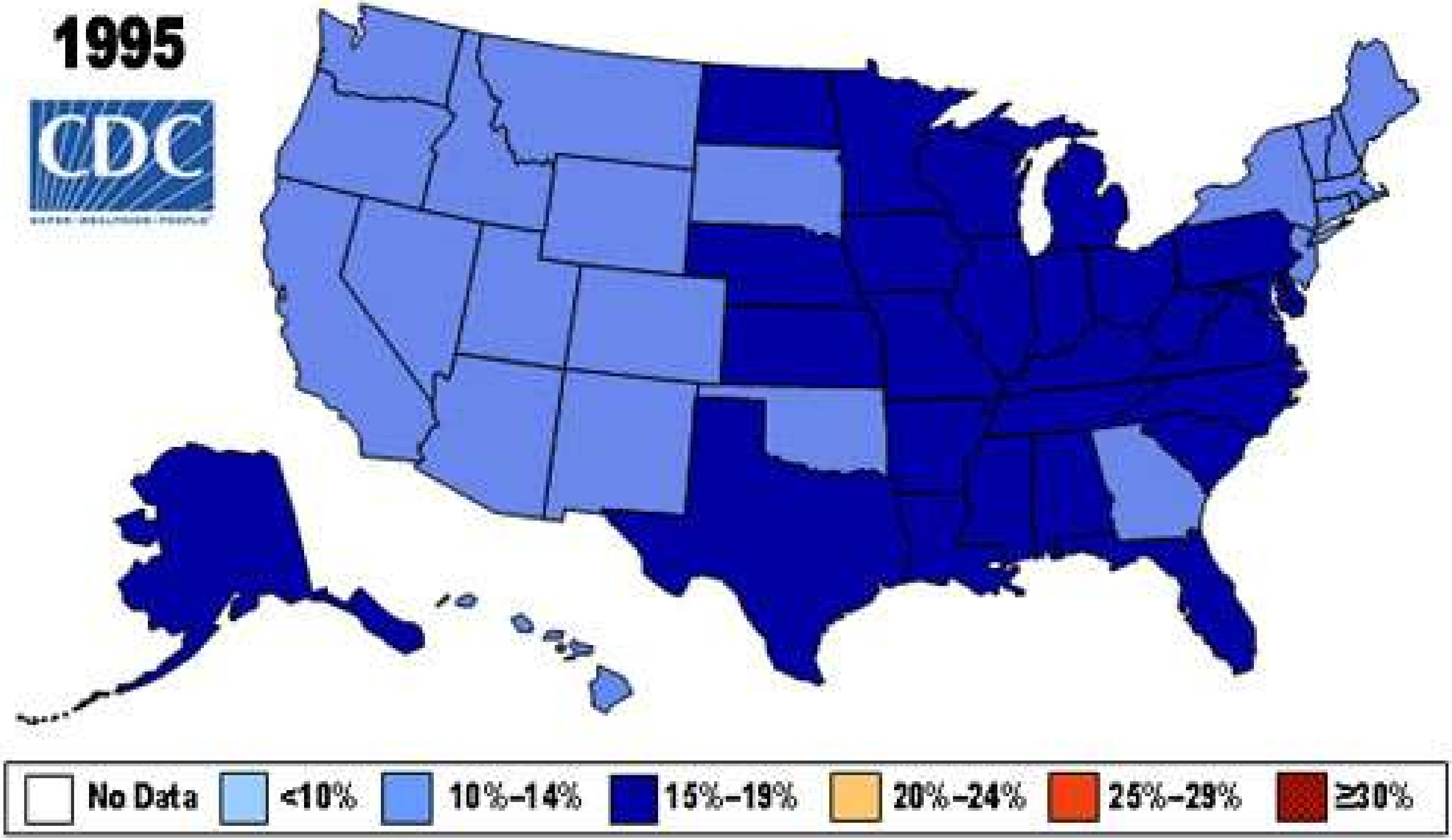


1988

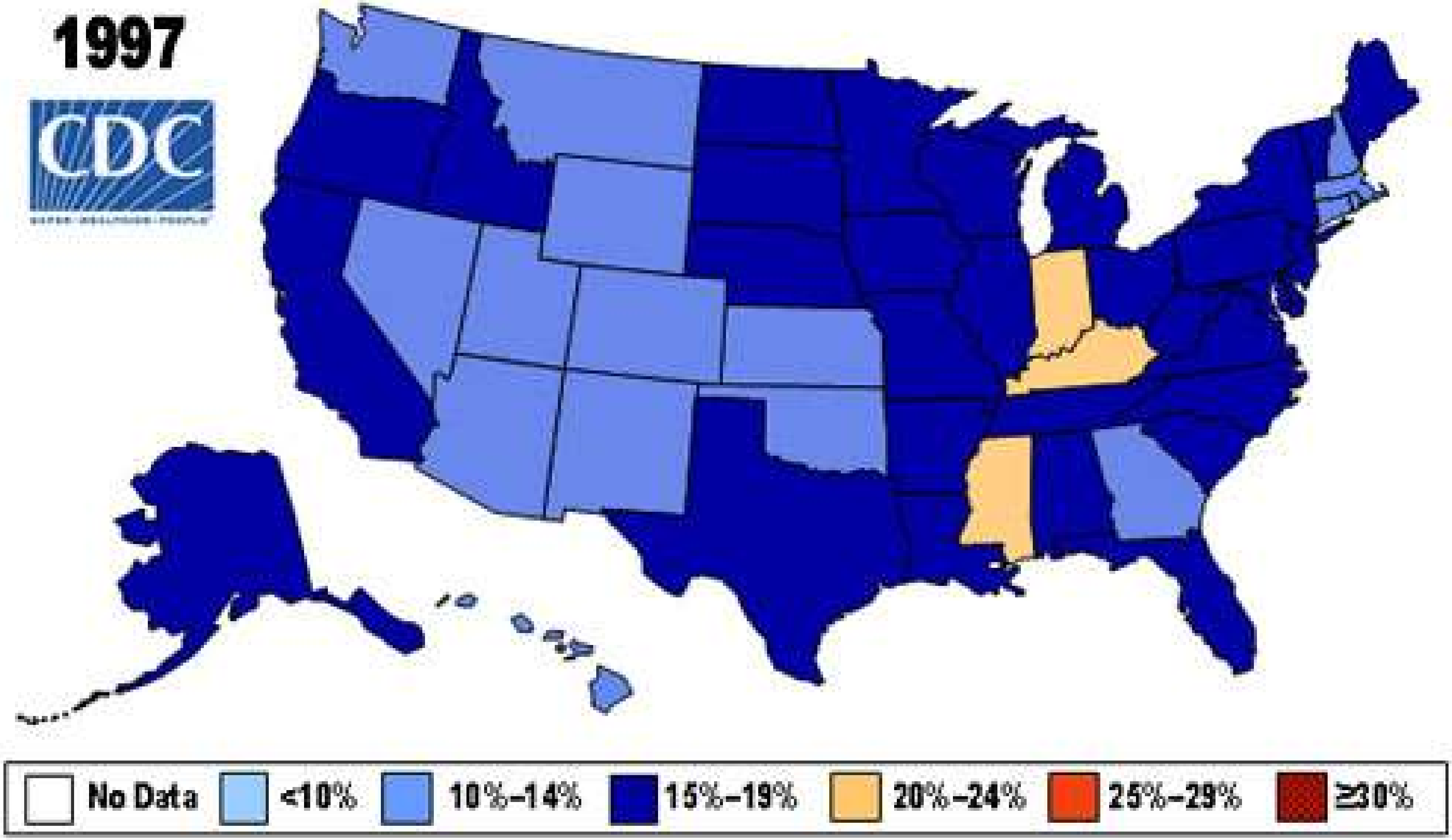


1990

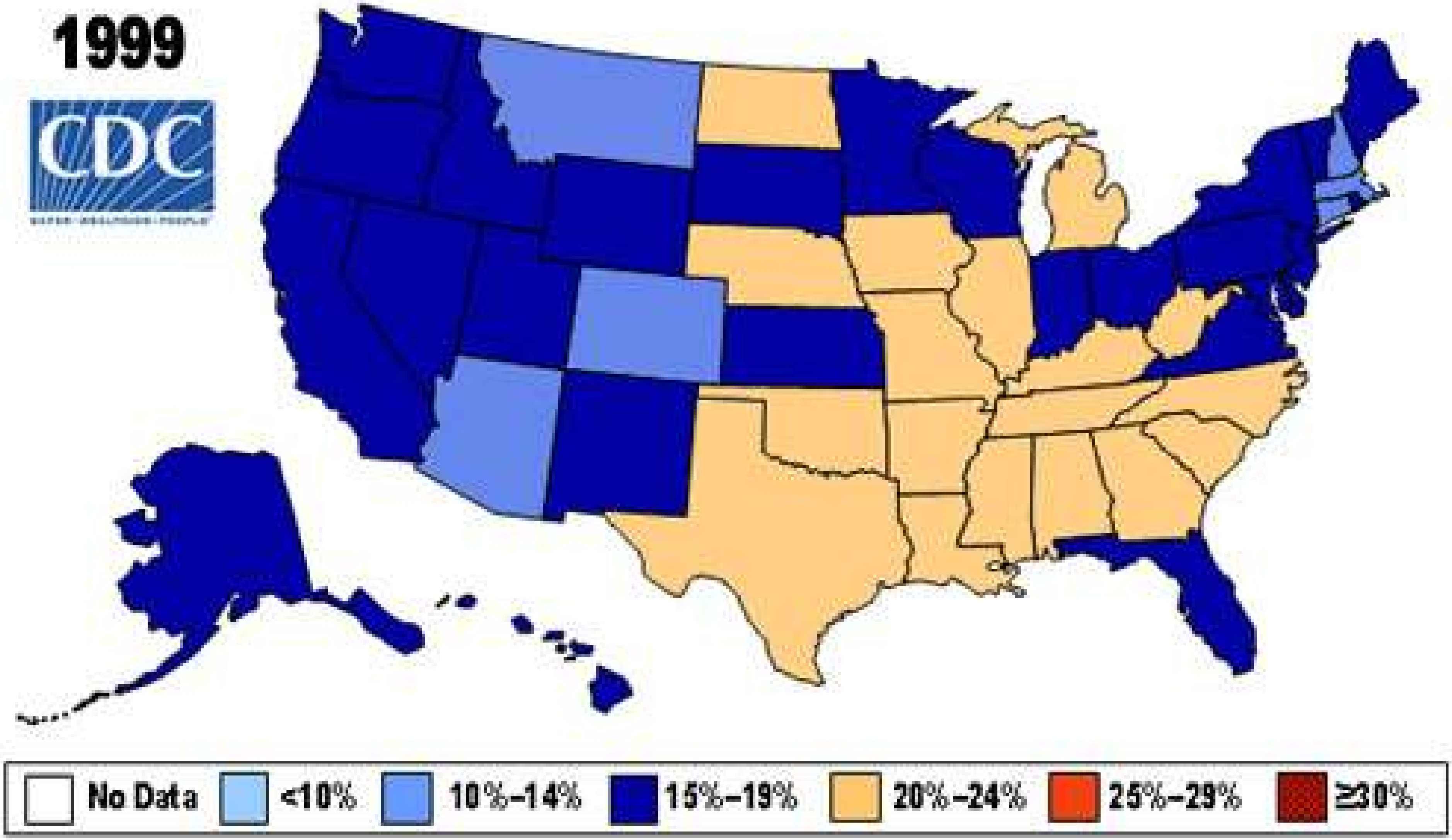


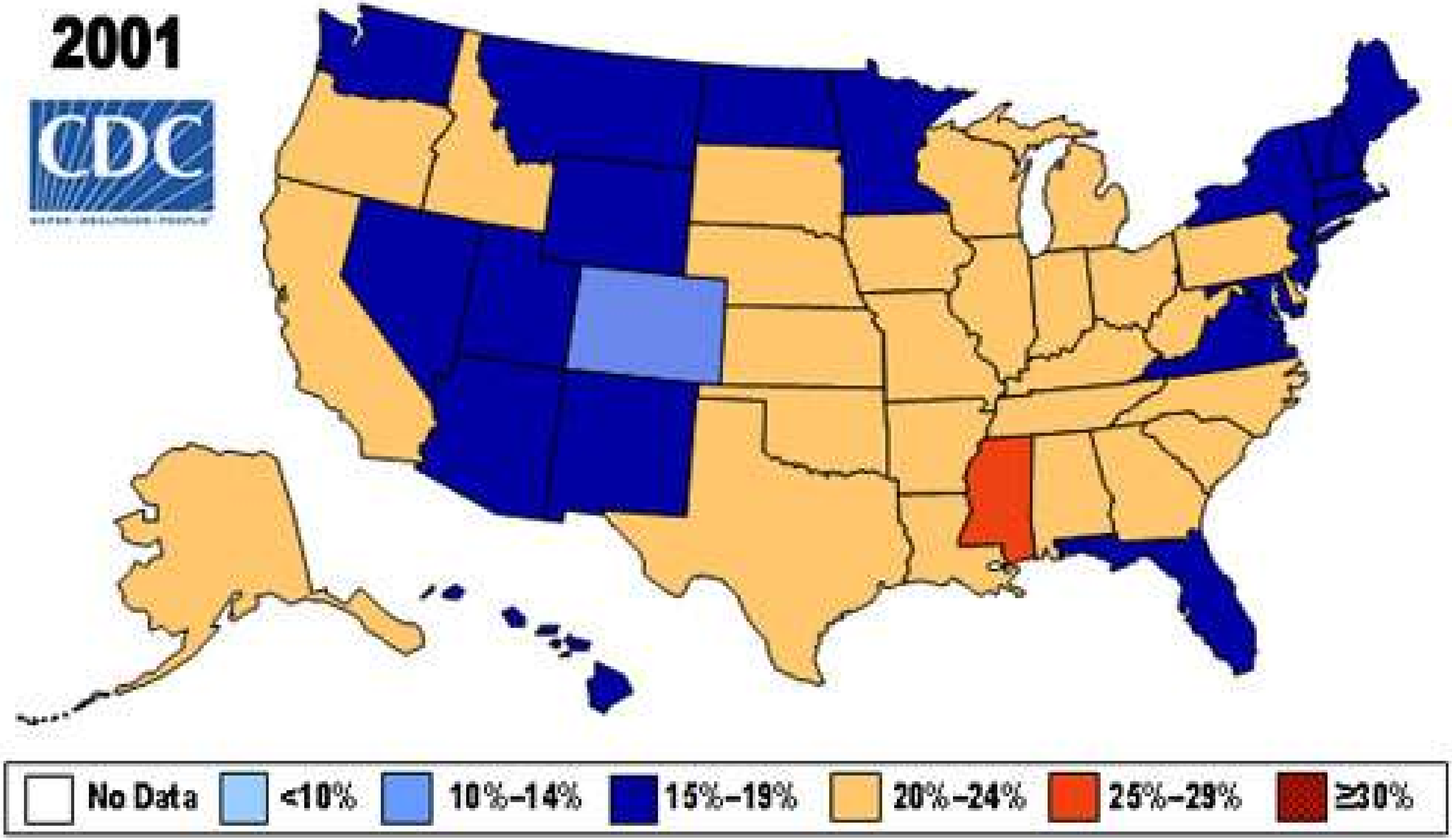

1995
CDC
No Data
<10%
10%–14%
15%–19%
20%–24%
25%–29%
≥30%

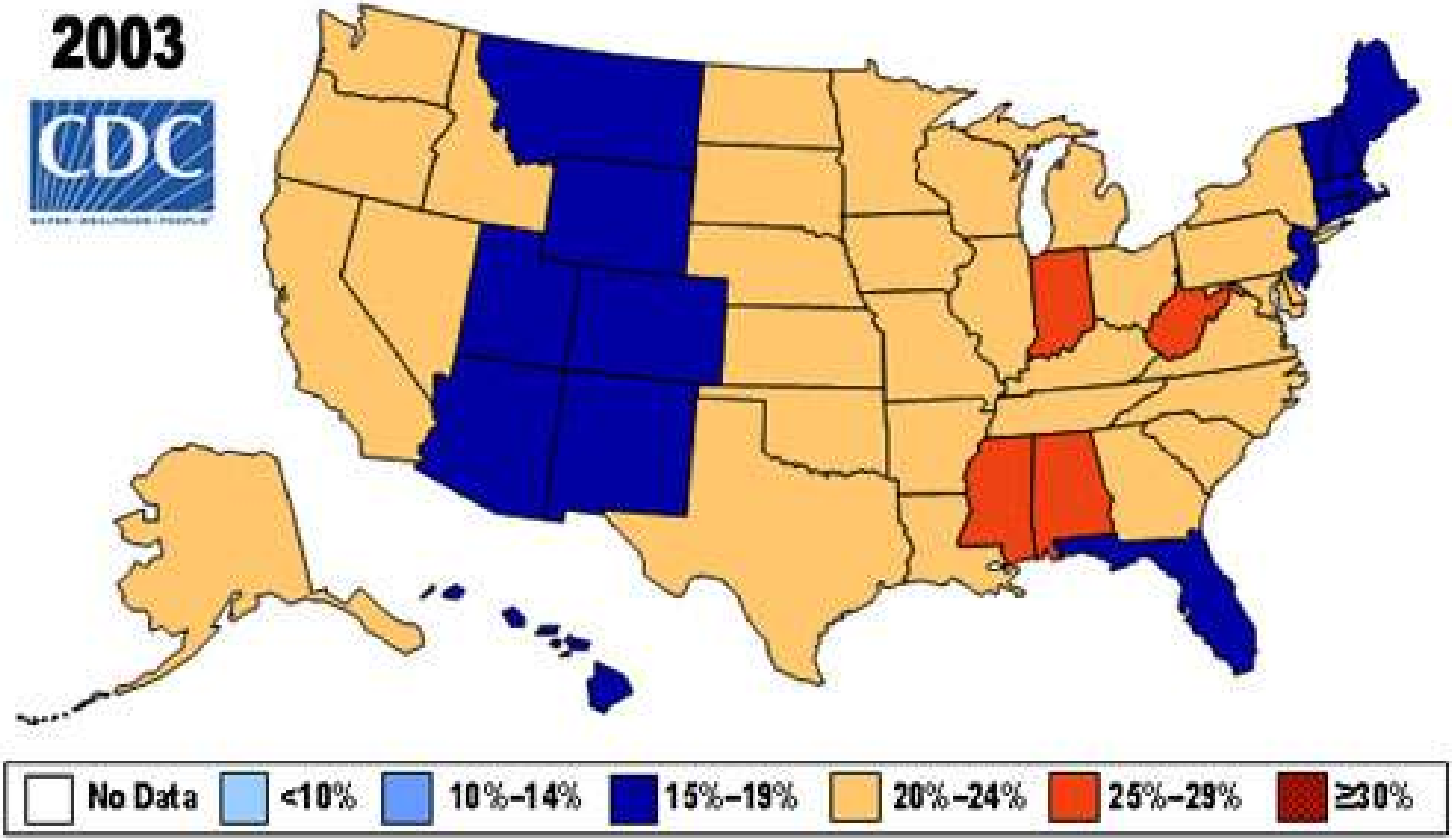
1997



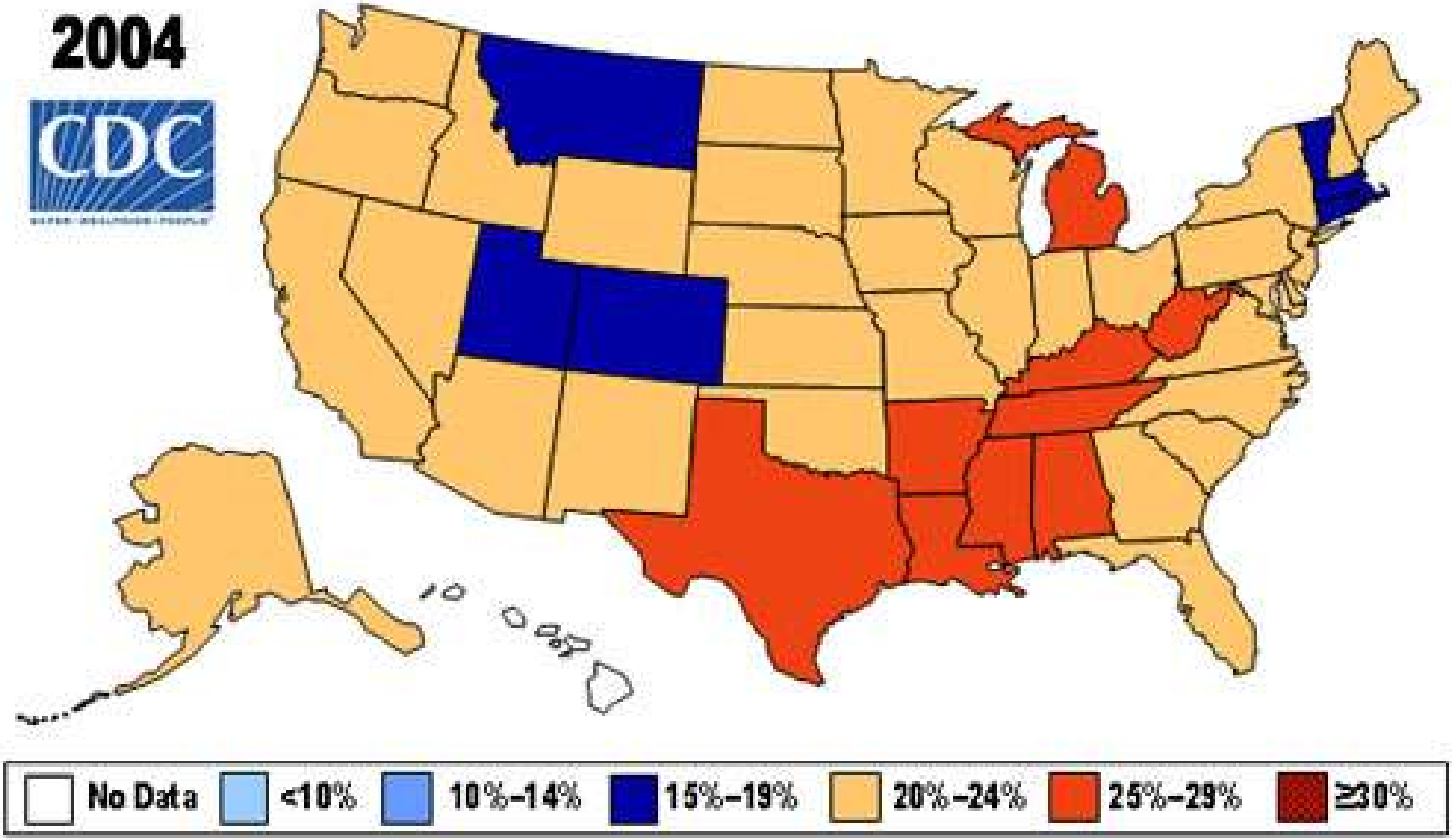
1999

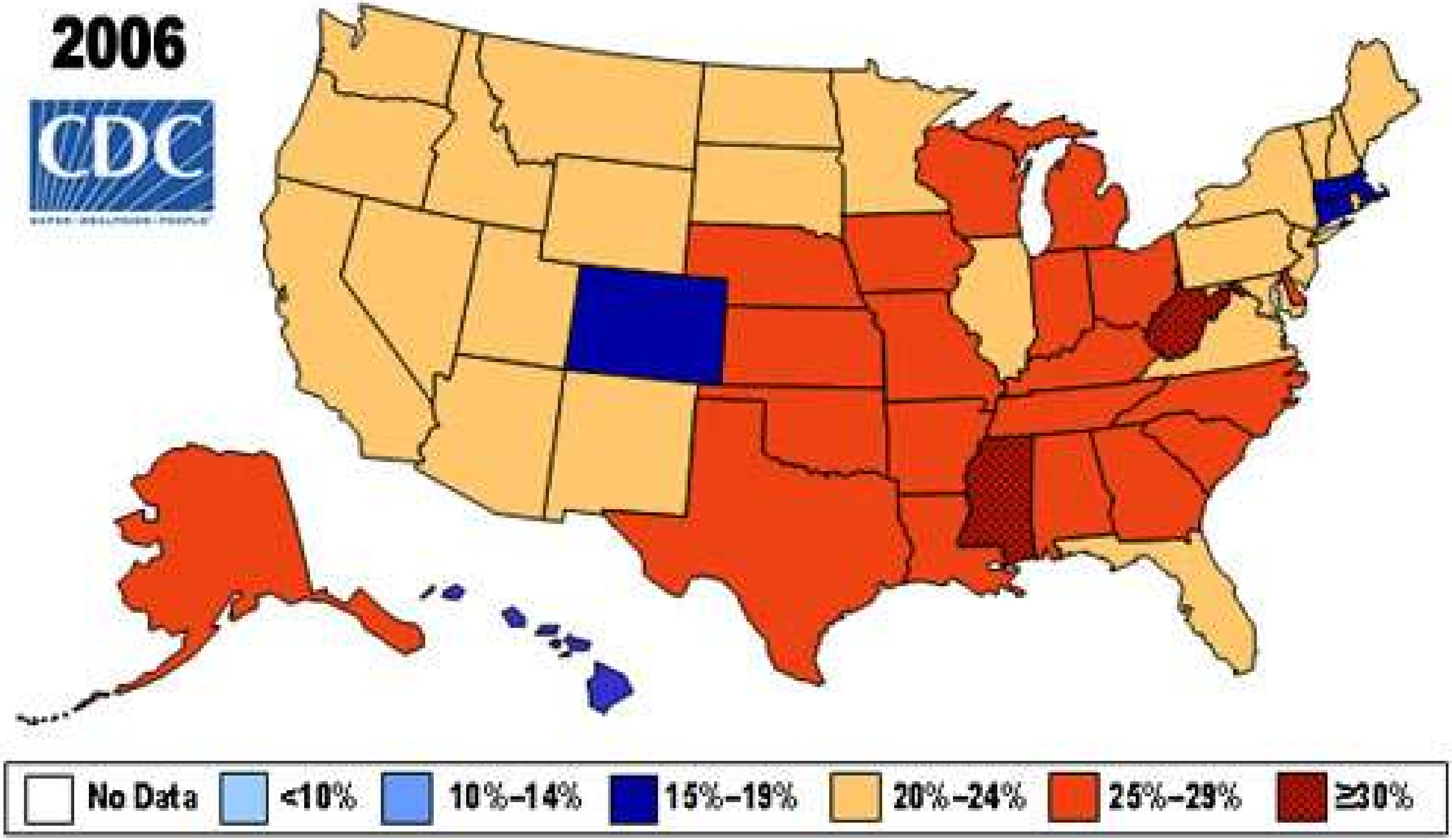



2001
CDC
No Data
<10%
10%–14%
15%–19%
20%–24%
25%–29%
≥30%

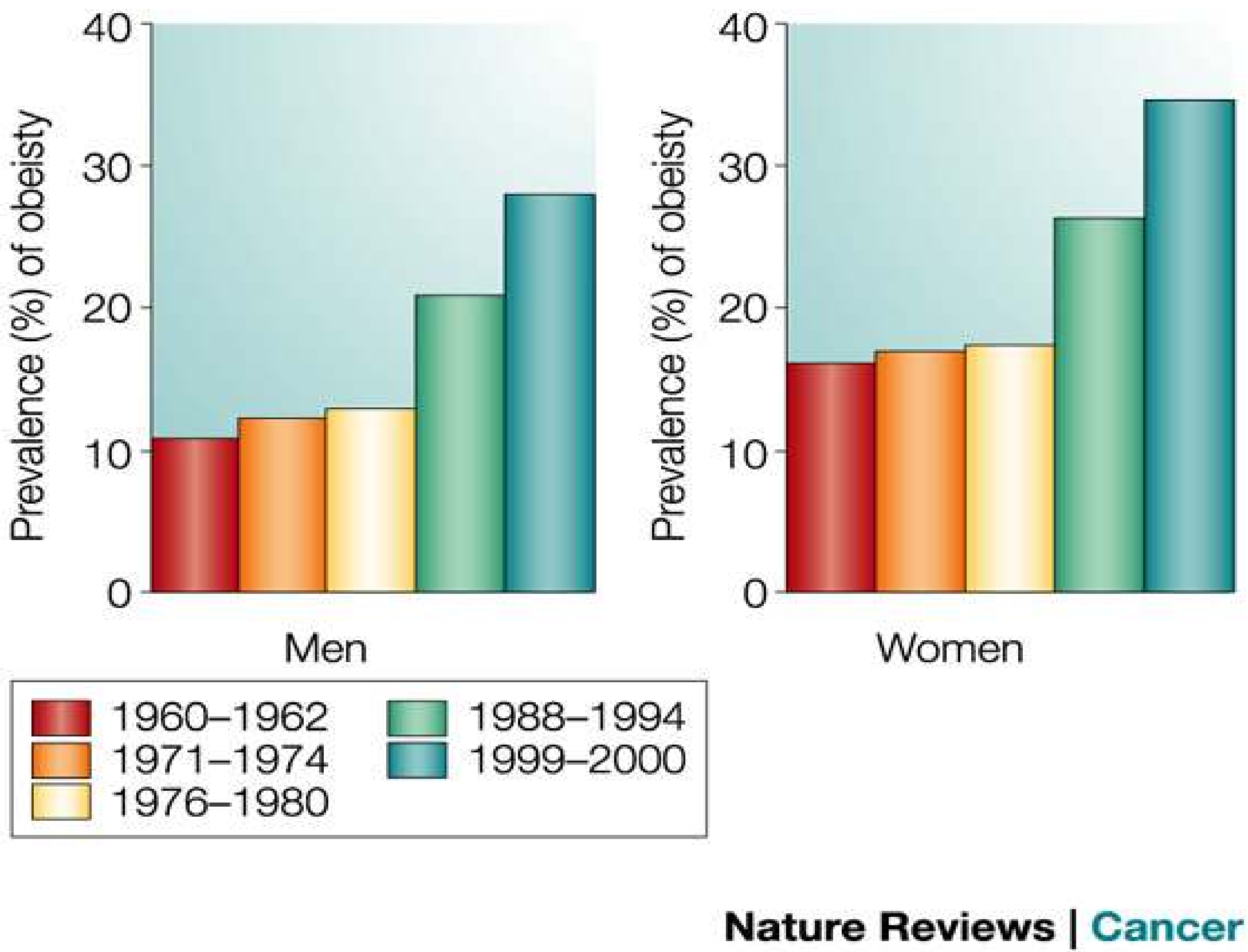

2003
No Data
<10%
10%–14%
15%–19%
20%–24%
25%–29%
≥30%

2004

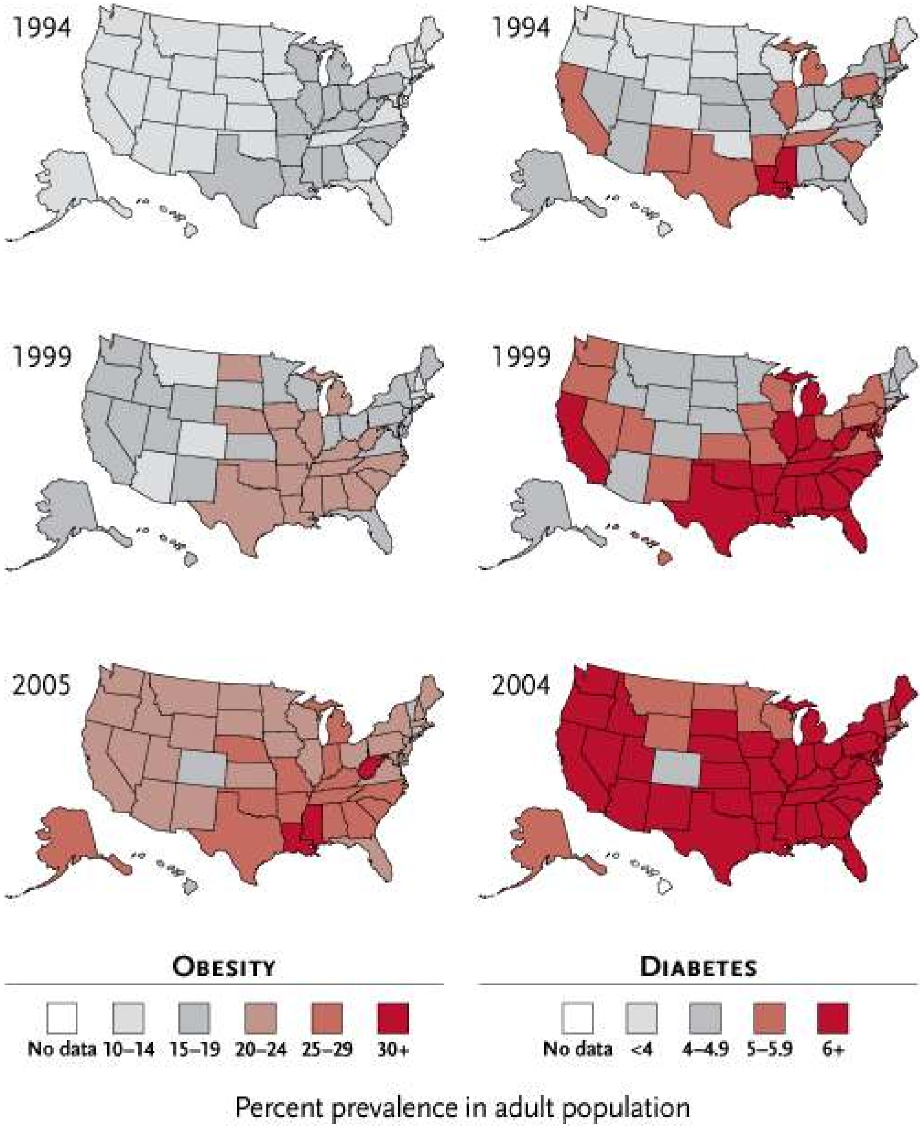



2006
CDC
No Data
<10%
10%–14%
15%–19%
20%–24%
25%–29%
≥30%

Obesity Trend



Obesity and Diabetes MAP

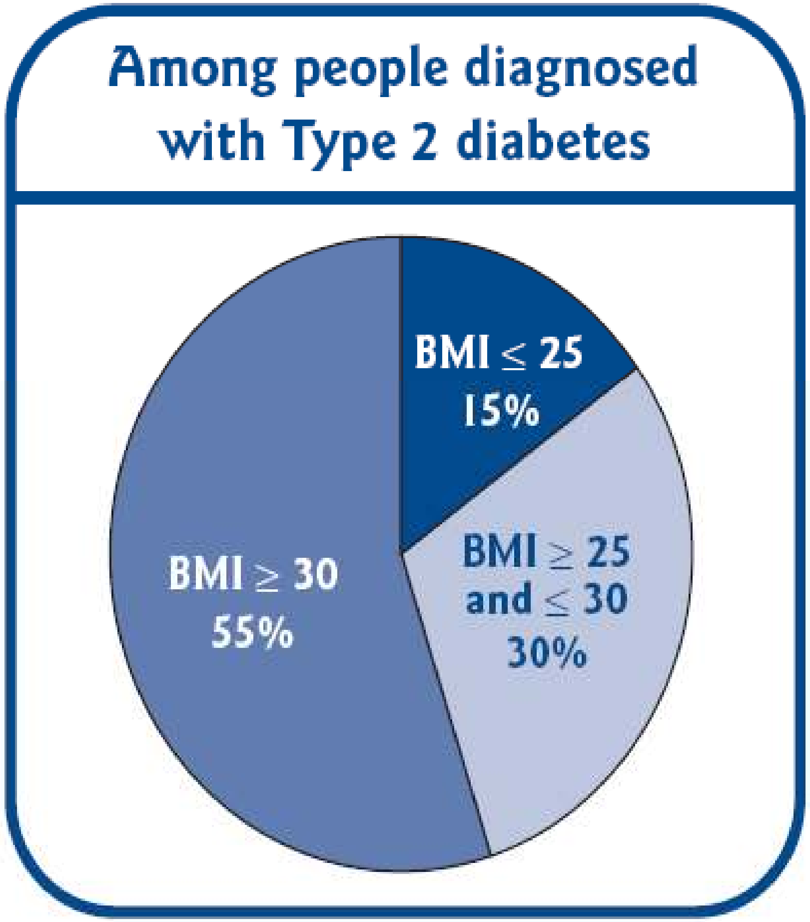


Adapted from CDC

Obesity and Type 2 diabetes

Prevalence of Obesity-Related Conditions

Among people diagnosed with Type 2 diabetes, 85 percent have a BMI $\geq$ 25 (classified as falling within the overweight range) and 55 percent have a BMI $\geq$ 30 (classified as obese)[67].



Korean Adolescents Physical Activity (KAPHA) study

- Three year follow up study
  - From 1st year to 3rd year high school students
- Total 504 students (Varies each year)
  - First year 225
  - Second 324
- Physical activity questionnaire
- Dietary record
- Physical fitness (6 different tests)
- Body composition
- HOMA, Blood lipids, IGF-1, IGFBP-3
- Cardiovascular disease risk score
- Intima media thickness

Obesity increased insulin resistance and CVD risk factors among adolescents (2nd year)

Variables	Normal (N=211)	At risk of overweight (N=95)	Overweight (N=18)
BMI (kg/m2)	20.26±1.62	24.61 ±1.1*	29.89 ±2.32**
Body fat(%)	16.29 ±3.74	23.15 ±3.28*	30.64 ±4.01**
Glucose (mg/dl)	72.36 ±7.91	71.37 ±8.2	69.72 ±13.56
HOMA-IR	.85 ±.52	1.18 ±.66*	1.82 ±.78**
TG (mg/dl)	85 ±39	94 ±47	117 ±47**
TC (mg/dl)	148±24	149±26	161 ±22**
HDL-C (mg/dl)	47 ±8	43 ±8*	41 ±9*
Hs-CRP	.15 ±.42	.11 ±.22	.11 ±.13

Obesity increased the CVD risk score

- CVD risk score
  - Z-score for TC, HDL-C, TG, HOMA, and MAP were calculated. Z-score for HDL-C was multiplied by -1. Then all scores were added to make CVD risk score.

Variables	Normal (N=211)	At risk of overweight (N=95)	Overweight (N=18)
BMI (kg/m2)	20.26±1.62	24.61 ±1.1	29.89 ±2.32
CVD risk score	-1.15±2	1.62±2.5*	4.72±2.9**

Effects of level of fitness on insulin resistance and cardiovascular disease risk factors among Korean youth

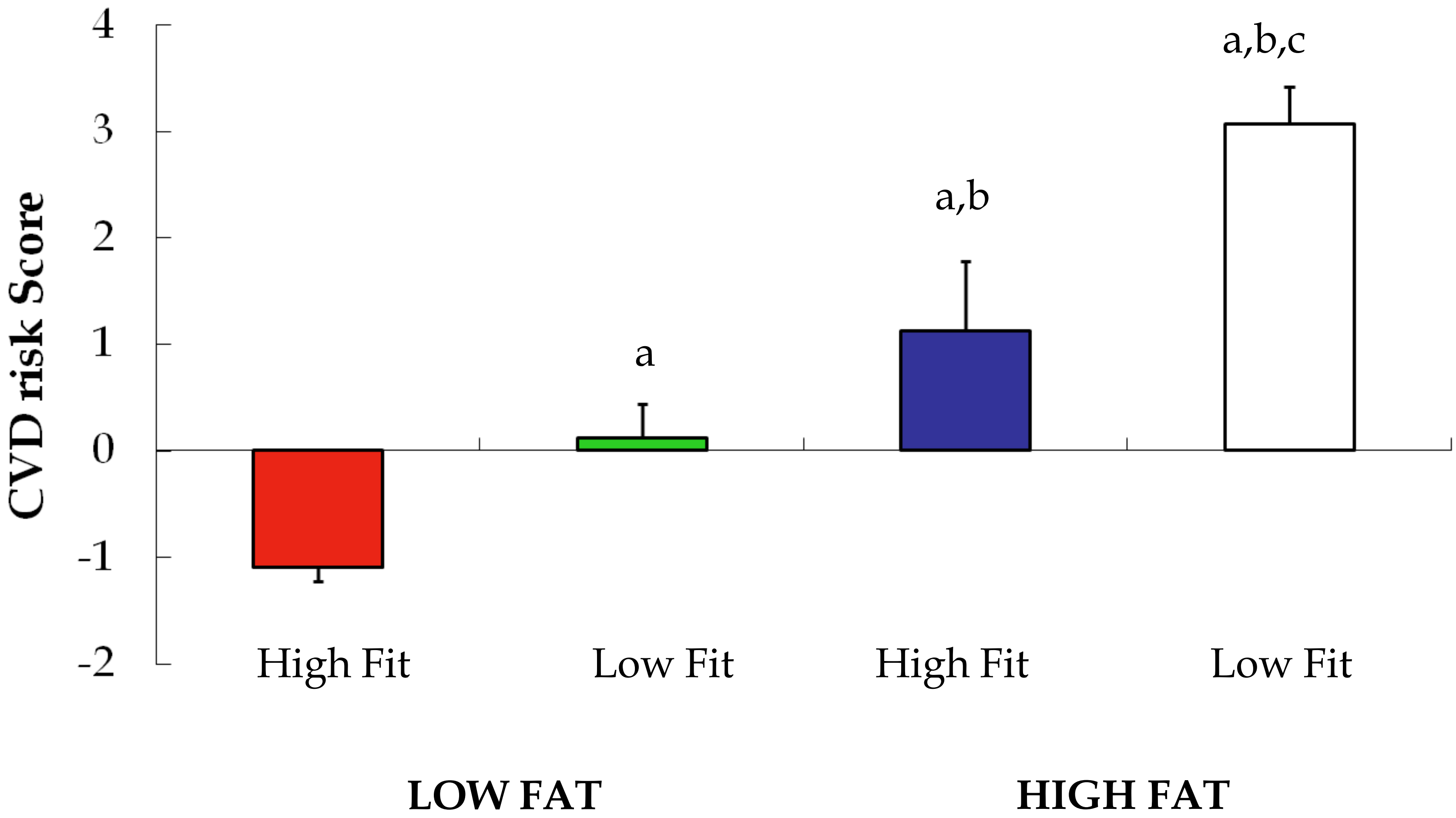
Mean±SD	1급 (N=75)	2급 (N=71)	3급 (N=40)	4급 (N=19)	5급 (N=14)
체질량지수	20.79±2.22	21.29±2.64	21.09±3.48	23.65±4.46*^+	27.19±3.99*^+#
인슐린	5.26±2.64	5.36±3.15	5.18±3.08	9.40±5.37*^+	7.62±3.27
인슐린 저항성 지수	.95±.49	.97±.58	.94±.58	1.71±1.03*^+	1.42±.70
허리둘레	73.58±6.18	74.14±6.67	73.81±8.54	81.42±9.35*^+	89.04±10.72*^+#
심혈관질환 위험지수	-.35±2.51	-.35±2.65	-.79±2.57	2.06±4.41*^+	3.45±3.44*^+
경동맥 내중막 두께	.64±.05	.62±.06	.62±.06	.63±.08	.76±.29*^+
체지방률	17.18±4.32	19.39±4.57	20.80±6.01*	23.56±6.33*^	31.37±3.74*^+#

1st, 총합점수가 가장 낮은 하위 25%그룹; 4th, 총합점수가 가장 높은 하위 25% 그룹

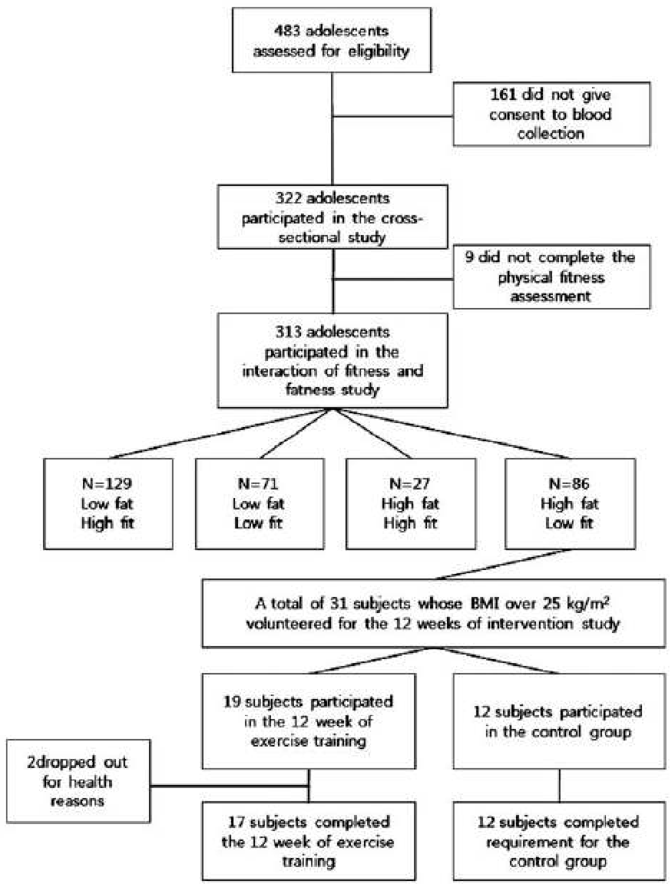
*1급, ^2급, +3급, #4급과 통계적으로 유의한 차이가 있음

본 연구의 결과는 총 516명의 청소년을 3년간 추적하여 저들의 신체활동과, 심혈관질환 위험요인을 조사한 Korean Adolescents Physical Activity (KAPHA) Study 의 1년차 연구 데이터임 제갈윤석 (2008) 한국체육학회지 47:485-493

Effects of Fatness and Cardiovascular Fitness on CVD risk Score

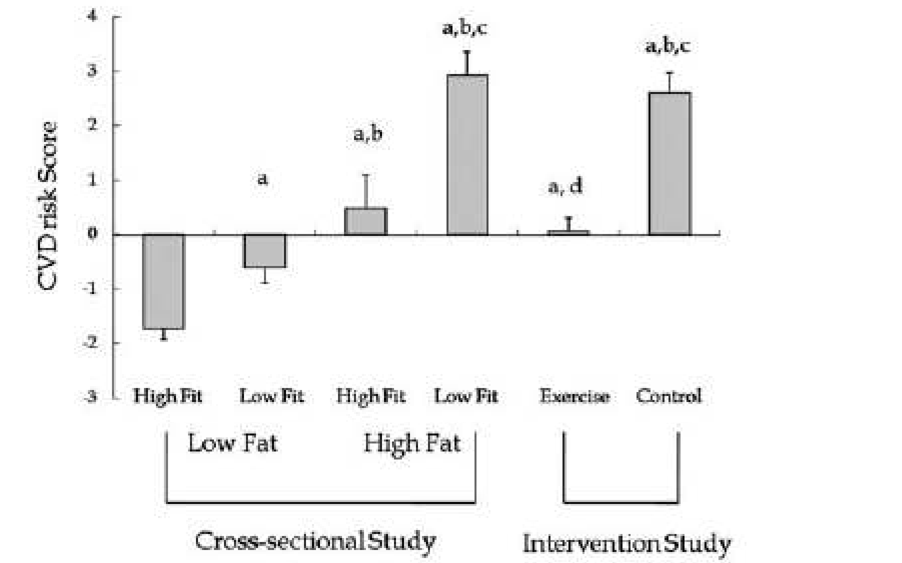


Interaction Between Fatness and Fitness on CVD Risk Factors in Asian Youth



Insulin resistance, CVD risk factors, IMT and CVD risk scores were compared among four groups during cross-sectional study. During intervention study, the exercise group trained five times per week, 50 min per day for 12 weeks. They expended 1500 kcal for the first four week, then to 1800 kcal for the next four weeks and then to 2500 kcal per week for the last four week of the study.

Fig. 1 Flowchart for enrollment, categorization and exercise intervention.



High fat group include at risk of overweight and overweight. Subjects whose VO_2max over 49.6 ml/kg/min were categorized as high fit. A total of 29 high-fat-low-fit subjects participated in the 12 weeks of intervention study. a $p<0.05$ vs low-fat-high-fit, b $p<0.05$ vs low-fat-low-fit c $p<0.05$ vs high-fat-high-fit d $p<0.05$ vs high-fat-low-fit and control in intervention study

Fig. 2 Interaction of fatness and fitness on CVD risk score.

Y. Jekal[1*], E. S. Kim[1*], J. A. Im[2], J. H. Park[1], M. K. Lee[1], S. H. Lee[1], S. H. Suh[3], S. H. Chu[4], E. S. Kang[5], H. C. Lee[5], J. Y. Jeon[1]

Int J Sports Med 2009; 30: 733–740

Reduced serum vaspin concentrations in obese children following short-term intensive lifestyle modification

Mi Kyung Lee [a,1], Yoonsuk Jekal [a,1], Jee-Aee Im [f], Eunsung Kim [a], Seung Hwan Lee [a], Ji-Hye Park [a], Sang Hui Chu [e], Kyong-Mee Chung [c], Hyun Chul Lee [b], Eui Geum Oh [e], Sang Hwan Kim [d], Justin Y. Jeon [a,*]

Table 1
Subject characteristics.

	Boys	Girls	Total
N	25	25	50
Age (y)	11.90 ± 0.80	12.00 ± 0.90	12.00 ± 0.90
Anthropometric measurement			
BMI (kg/m^2)	25.82 ± 2.33	24.89 ± 3.27	25.35 ± 2.85
Weight (kg)	57.13 ± 8.68	57.56 ± 11.72	57.35 ± 10.21
Muscle mass (kg)	18.84 ± 3.54	18.29 ± 3.87	18.5 ± 3.68
Fat (kg)	20.96 ± 5.10	20.99 ± 6.37	21.0 ± 5.68
WC (cm)	80.43 ± 6.53	73.88 ± 7.70*	77.2 ± 7.80
WHR	.93 ± .03	.86 ± .03*	.90 ± .048
Blood pressure			
SBP (mmHg)	114.48 ± 11.42	117.48 ± 13.47	115.98 ± 12.45
DBP (mmHg)	76.32 ± 10.51	77.80 ± 11.78	77.06 ± 11.07
Glucose metabolism			
Glucose (mmol/l)	4.66 ± 0.36	4.63 ± 0.30	4.65 ± 0.31
Insulin (pmol/l)	122.23 ± 64.40	126.20 ± 66.10	124.20 ± 64.40
HOMA-IR	3.54 ± 1.95	3.63 ± 1.96	3.58 ± 1.93
HOMA-beta	68.32 ± 37.40	71.02 ± 38.00	69.67 ± 37.30
Lipid profiles			
TC (mmol/l)	4.25 ± 0.63	4.27 ± 0.60	4.26 ± 0.61
HDL-C (mmol/l)	1.25 ± 0.27	1.40 ± 0.19*	1.32 ± 0.24
TG (mmol/l)	1.59 ± 0.80	1.11 ± 0.49*	1.35 ± 0.69
Inflammatory markers			
hs-CRP (mg/dL)	.21 ± .21	.16 ± .28	.189 ± .25
Vaspin (ng/ml)	.75 ± .10	.94 ± 1.01	.84 ± 1.00
Adiponectin (ng/ml)	5.89 ± 2.34	7.13 ± 3.44	6.50 ± 2.98

Table 3
Multivariate analysis to assess relationships between glucose metabolism-related parameters and vaspin.

Dependent variable	Variables	β	S.E	Standardized β	*P*-value
Model 1					
Glucose	BMI	−0.249	0.546	−0.127	NS
	Vaspin	−0.912	0.872	−0.170	NS
Model 2[a]					
Insulin	BMI	2.233	0.708	0.681	0.003
	Vaspin	−2.292	1.129	−0.255	0.049
Model 3[b]					
HOMA-IR	BMI	−0.452	0.157	0.633	0.007
	Vaspin	−0.514	0.251	−0.263	0.047

All regression coefficients were adjusted for age, sex, waist hip ratio, and triglycerides. BMI: body mass index, Vaspin: visceral adipose tissue-derived serpin, HOMA-IR: homeostasis model assessment of insulin resistance.

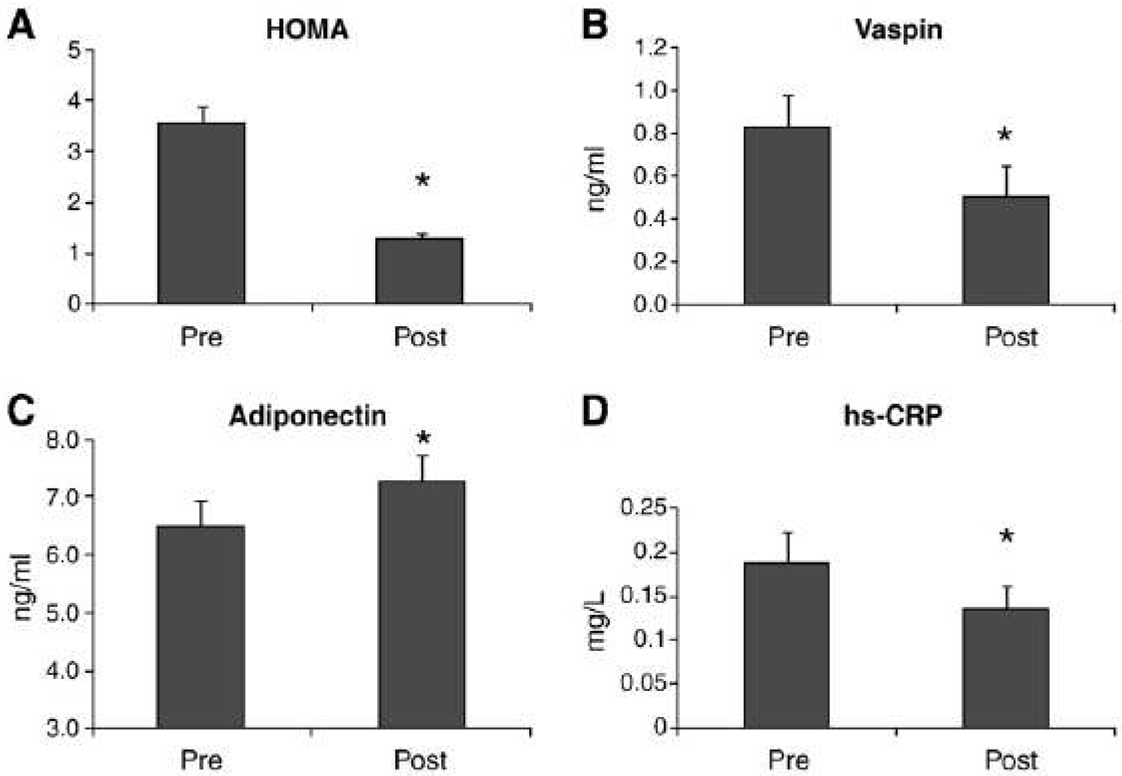
[a] Plasma vaspin levels account for insulin levels by 47.3% (R^2; 0.473, *F*-value 5.823, $p<0.0001$).

[b] Plasma vaspin levels account for HOMA-IR by 45% (R^2; 0.450, *F*-value 5.319, $p=0.001$).

본 연구는 초등학교 4-6학년 어린이를 대상으로 7일간의 비만 치료 프로그램이 만성질환 위험요인과 인슐린 저항성 그리고 Vaspin 에 미치는 영향을 분석한 총 2년에 걸친 연구이며 이중 1년차 연구의 결과이다.

Reduced serum vaspin concentrations in obese children following short-term intensive lifestyle modification

Mi Kyung Lee [a,1], Yoonsuk Jekal [a,1], Jee-Aee Im [f], Eunsung Kim [a], Seung Hwan Lee [a], Ji-Hye Park [a], Sang Hui Chu [e], Kyong-Mee Chung [c], Hyun Chul Lee [b], Eui Geum Oh [e], Sang Hwan Kim [d], Justin Y. Jeon [a,*]



본 연구는 초등학교 4-6학년 어린이를 대상으로 7일간의 비만 치료 프로그램이 만성질환 위험요인과 인슐린 저항성 그리고 Vaspin 에 미치는 영향을 분석한 총 2년에 걸친 연구이며 이중 1년차 연구의 결과이다.

Is fitness better predictor than fatness for increased mortality?

Table 7. Joint Associations of Cardiorespiratory Fitness (Fitness) and Adiposity Measures With All-Cause Mortality—Aerobics Center Longitudinal Study, 1979-2003[a]

	Fit			Unfit			
Adiposity Measure	No. of Deaths	Rate[b]	HR (95% CI)[c]	No. of Deaths	Rate[b]	HR (95% CI)[c]	*P* Value
BMI[d]							
18.5-24.9	158	1.2	1 [Reference]	34	4.9	3.63 (2.47-5.32)	<.001
25.0-29.9	152	1.2	0.88 (0.70-1.11)	44	2.7	1.74 (1.23-2.46)	<.001
30.0-34.9	32	1.6	1.12 (0.76-1.66)	18	2.5	1.68 (1.02-2.78)	.46
≥35.0	2	1.2	0.86 (0.21-3.50)	10	4.8	3.35 (1.74-6.44)	.05
Waist circumference[e]							
Normal	274	5.1	1 [Reference]	61	14.5	2.84 (2.15-3.75)	<.001
Abdominal obesity	70	6.2	1.21 (0.93-1.58)	45	13.5	2.65 (1.93-3.63)	<.001
Percent body fat[e]							
Normal	151	9.1	1 [Reference]	29	26.8	2.94 (1.97-4.38)	<.001
Obese	190	8.7	0.96 (0.78-1.19)	72	21.8	2.39 (1.81-3.16)	<.001

Abbreviations: BMI, body mass index; CI, confidence interval; HR, hazard ratio.
[a] Cross-product tests of interaction between fitness and adiposity exposures were not statistically significant: fitness-BMI ($\chi^2_1 = 0.05$, $P = .82$); fitness-waist circumference ($\chi^2_1 = 1.38$, $P = .24$); and fitness-percent body fat ($\chi^2_1 = 0.04$, $P = .84$).
[b] All-cause death rates per 1000 person-years adjusted for age, sex, and examination year.
[c] Adjusted for age, sex, examination year, smoking status, abnormal exercise electrocardiogram responses, and presence vs absence of baseline health conditions (cardiovascular disease, hypertension, diabetes, and hypercholesterolemia).
[d] Calculated as weight in kilograms divided by height in meters squared.
[e] See "Methods" for definitions.

Xui X et al. 2007 298:2507-2516 JAMA

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

Fatness Is a Better Predictor of Cardiovascular Disease Risk Factor Profile Than Aerobic Fitness in Healthy Men

Demetra D. Christou, PhD; Christopher L. Gentile, MS; Christopher A. DeSouza, PhD; Douglas R. Seals, PhD; Phillip E. Gates, PhD

Circulation 2005;111;1904-1914

TABLE 2. Independent Relation of Aerobic Fitness and Fatness to Metabolic Risk Factors

	BMI Model		Total Body Fat Model		Waist Model	
	$\dot{V}O_2$max, mL · kg^{-1} · min^{-1}	BMI, kg/m^2	$\dot{V}O_2$max, mL · kg^{-1} · min^{-1}	Total Body Fat, %	$\dot{V}O_2$max, mL · kg^{-1} · min^{-1}	Waist, cm
Total cholesterol, mmol/L	NS	0.31‡	NS	0.36‡	NS	0.35‡
HDL cholesterol, mmol/L	NS	−0.19*	NS	−0.24*	NS	−0.26†
LDL cholesterol, mmol/L	NS	0.23†	NS	0.28†	NS	0.27†
Ratio of total to HDL cholesterol	NS	0.38‡	NS	0.40‡	NS	0.44‡
Triglycerides, mmol/L	−0.16*	0.35‡	NS	0.42‡	NS	0.44‡
Fasting insulin, pmol/L	−0.21†	0.42‡	NS	0.44‡	NS	0.51‡
Insulin sensitivity, $\times 10^{-5}$ · min^{-1} · pmol/L^{-1}	0.19*	−0.40‡	NS	−0.44‡	NS	−0.33‡

Values are part correlation coefficients derived from multiple linear regression analysis. The BMI model included $\dot{V}O_2$max, BMI, and age as independent variables; the total body fat model included $\dot{V}O_2$max, total percent body fat, and age; and the waist model included $\dot{V}O_2$max, waist circumference, and age.

*$P<0.05$; †$P\leq0.01$; ‡$P\leq0.0001$.

Both fatness and fitness good predictors for IFG and type 2 DM

Type 2 diabetes					
Fitness level					
1 (low)	94	10,640	12.4	1.00 (referent)	1.00 (referent)
2	102	17,802	5.6	0.65 (0.49–0.86)	0.80 (0.60–1.08)
3	102	20,331	4.5	0.53 (0.40–0.71)	0.71 (0.52–0.96)
4	101	25,460	3.5	0.43 (0.32–0.58)	0.62 (0.45–0.85)
5 (high)	78	27,162	2.4	0.30 (0.22–0.41)	0.48 (0.34–0.68)
P_{trend}				<0.001	<0.001
BMI					
18.5–25.0 kg/m^2	146	49,226	2.9	1.00 (referent)	1.00 (referent)
25.0–29.9 kg/m^2	231	44,491	5.1	1.59 (1.29–1.97)	1.36 (1.09–1.69)
≥30.0 kg/m^2	100	7,677	14.0	3.85 (2.93–5.06)	2.66 (1.96–3.60)
P_{trend}				<0.001	<0.001
Waist girth‖					
≤102 cm	218	57,692	3.8	1.00 (referent)	1.00 (referent)
>102 cm	102	8,835	11.6	2.66 (2.08–3.41)	1.91 (1.46–2.50)
% body fat					
<25%	316	82,071	4.0	1.00 (referent)	1.00 (referent)
≥25%	161	19,328	7.9	1.79 (1.47–2.18)	1.27 (1.02–1.58)

*Per 1,000 person-years adjusted for age and examination year. †Adjusted for age, examination year, parental diabetes, current smoking, alcohol consumption, systolic and diastolic blood pressure, total cholesterol, and IFG (for type 2 diabetes). ‡Adjusted for model 1 plus BMI (for fitness) or treadmill time (for BMI, waist girth, and percent body fat). §Data from 5,836 men (2,563 IFG events). ‖Data from 10,326 men (320 type 2 diabetes events).

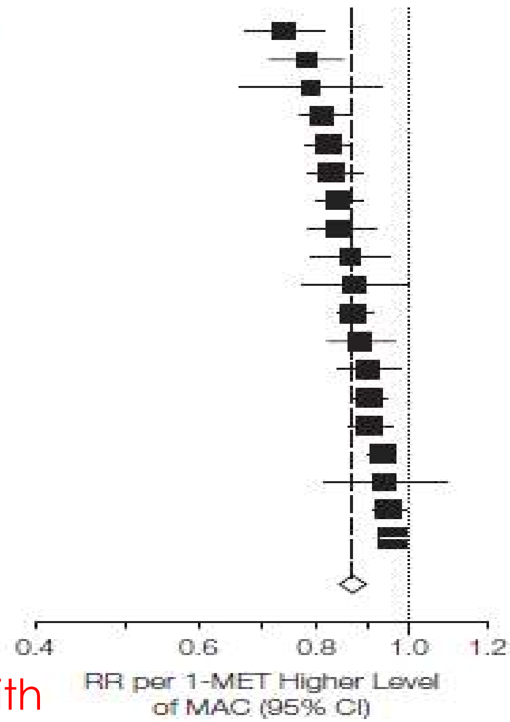
Lee DC et al. 2009 32:257-262 Diabetes Care

Both fatness and fitness good predictors for IFG and type 2 DM

Figure 2. Meta-analysis of All-Cause Mortality and CHD/CVD per 1-MET Higher Level of MAC

Source	Weight, %	RR (95% CI)
All-cause mortality		
Erikksen et al,[36] 1998	4.46	0.74 (0.67-0.81)
Aktas et al,[30] 2004	4.52	0.78 (0.71-0.85)
Miller et al,[6] 2005	2.33	0.78 (0.66-0.93)
Katzmarzyk et al,[45] 2005	6.01	0.81 (0.77-0.86)
Laukkanen et al,[8] 2007	5.78	0.82 (0.77-0.87)
Gulati et al,[39] 2005	5.59	0.83 (0.78-0.89)
Myers et al,[47] 2002	5.84	0.84 (0.79-0.89)
Sawada and Muto,[51] 1999	4.85	0.85 (0.78-0.92)
Arraiz et al,[32] 1992	4.45	0.87 (0.79-0.95)
Sandvik et al,[50] 1993	3.38	0.88 (0.77-1.00)
Mora et al,[46] 2003	6.43	0.88 (0.84-0.92)
Stevens et al,[21] 2002 [women]	4.99	0.89 (0.82-0.96)
Farrell et al,[38] 2002	5.27	0.91 (0.84-0.98)
Aijaz et al,[29] 2008	6.64	0.91 (0.87-0.94)
Stevens et al,[22] 2004	6.21	0.91 (0.87-0.96)
Stevens et al,[21] 2002 [men]	6.79	0.94 (0.91-0.97)
Villeneuve et al,[53] 1998	2.84	0.94 (0.81-1.09)
Hein et al,[42] 1992	6.77	0.95 (0.92-0.98)
Slattery and Jacobs,[5] 1988	6.85	0.96 (0.93-0.99)
Overall	100.00	0.87 (0.84-0.90)

Test for heterogeneity: $I^2 = 82.3\%$; $P < .001$

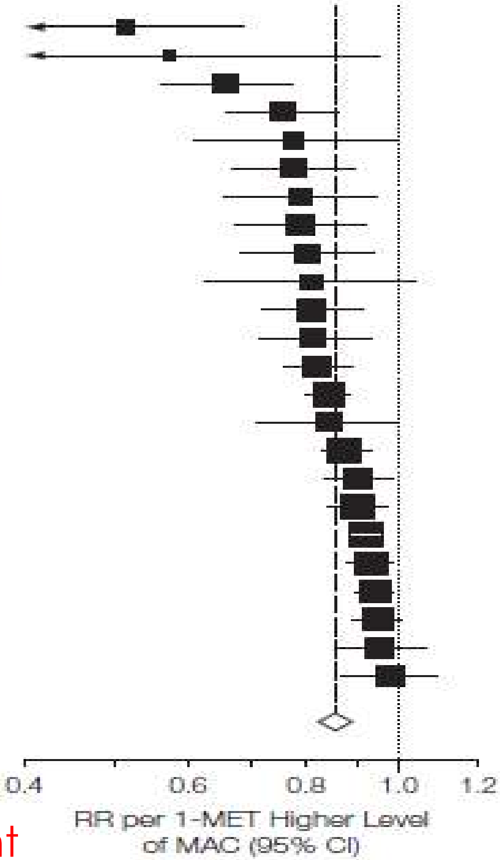


1-MET higher level of fitness was associated with 13% and 15% decrements in risk of all-cause mortality

Kodama et al. 2009 301:2024-2035 JAMA

Both fatness and fitness good predictors for IFG and type 2 DM

CHD/CVD		
Allen et al,[31] 1980 [women]	1.32	0.51 (0.38-0.68)
Sobolski et al,[52] 1987	0.49	0.57 (0.35-0.94)
Allen et al,[31] 1980 [men]	3.12	0.65 (0.56-0.76)
Bruce et al,[34] 1980	3.66	0.75 (0.65-0.85)
Peters et al,[48] 1983	1.70	0.77 (0.60-0.98)
Arraiz et al,[32] 1992	3.37	0.77 (0.66-0.89)
Miller et al,[6] 2005	2.54	0.78 (0.65-0.94)
Gulati et al,[39] 2005	3.11	0.78 (0.67-0.91)
Rywik et al,[49] 2002	2.98	0.79 (0.68-0.93)
Cumming et al,[35] 1975	1.58	0.80 (0.62-1.03)
Jouven et al,[43] 2005	4.22	0.80 (0.71-0.90)
Sawada and Muto,[51] 1999	3.77	0.81 (0.71-0.92)
Gyntelberg et al,[41] 1980	5.36	0.81 (0.75-0.88)
Mora et al,[46] 2003	6.59	0.83 (0.79-0.87)
Stevens et al,[21] 2002 [women]	2.83	0.83 (0.70-0.99)
Laukkanen et al,[8] 2007	6.28	0.87 (0.82-0.92)
Erriksen et al,[37] 2004	5.32	0.90 (0.83-0.98)
Stevens et al,[22] 2004	5.89	0.90 (0.84-0.96)
Sui et al,[7] 2007 [men]	7.18	0.91 (0.89-0.94)
Stevens et al,[21] 2002 [men]	6.48	0.93 (0.88-0.98)
Slattery and Jacobs,[5] 1988	6.86	0.94 (0.90-0.97)
Balady et al,[33] 2004 [men]	6.43	0.94 (0.89-0.99)
Sui et al,[7] 2007 [women]	4.67	0.94 (0.85-1.05)
Balady et al,[33] 2004 [women]	4.27	0.97 (0.87-1.09)
Overall	100.00	0.85 (0.82-0.88)
Test for heterogeneity: $I^2 = 74.7\%$; $P < .001$		



A minimal CRF of 7.9 METs may be important for significant prevention of all-cause mortality and CHD/CVD.

Kodama et al. 2009 301:2024-2035 JAMA

Cardiorespiratory Fitness as a Quantitative Predictor of All-Cause Mortality and Cardiovascular Events in Healthy Men and Women

A Meta-analysis

JAMA. 2009;301(19):2024-2035

- 1-MET higher level of fitness was associated with 13% and 15% decrements in risk of all-cause mortality and CHD/CVD, respectively.
- A minimal CRF of 7.9 METs may be important for significant prevention of all-cause mortality and CHD/CVD.

Age	CRF level
40 years old	9 and 7 METs
50 years	8 and 6 METs
60 years	7 and 5 METs

Effects of cardiorespiratory fitness on survival rates among patients with type 2 DM

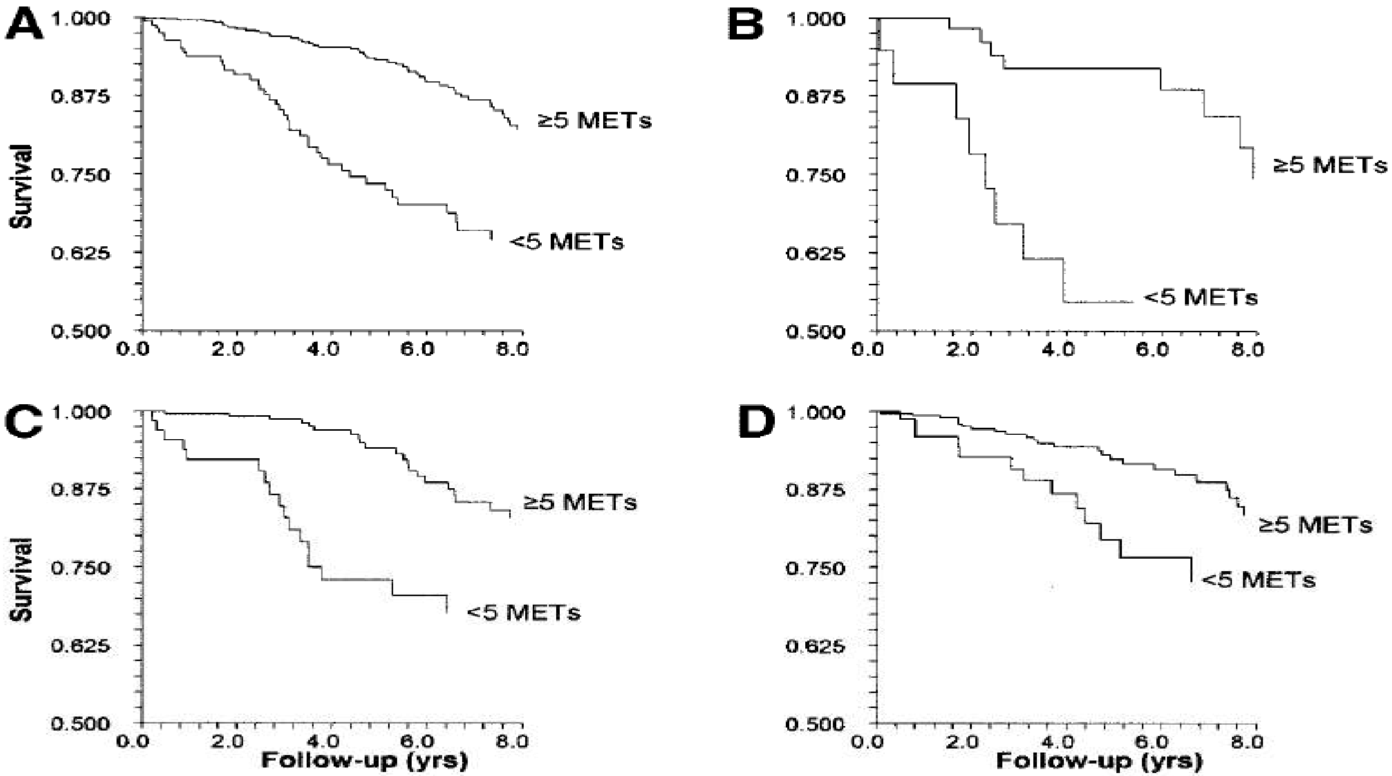


Figure 1— A: *Survival curves illustrating the probability of surviving with different levels of exercise capacity from 831 men with type 2 diabetes* (<5 *METs vs.* ≥ 5 *METs,* $P < 0.001$*).* B: *Survival curves in 78 normal-weight (BMI 18.5–24.9 kg/m*^{2}*) men with type 2 diabetes (*<5 *METs vs.* ≥ 5 *METs,* $P < 0.001$*).* C: *Survival curves in 330 overweight (BMI 25.0–29.9 kg/m*^{2}*) men with type 2 diabetes (*<5 *METs vs.* ≥ 5 *METs,* $P < 0.01$*).* D: *Survival curves in 423 obese (BMI* ≥ 30.0 *kg/m*^{2}*) men with type 2 diabetes (*<5 *METs vs.* ≥ 5 *METs,* $P < 0.05$*). The area under the survival curves is the total life expectancy for populations with an exercise capacity of* <5 *METs or an exercise capacity of* ≥ 5 *METs (VETS 1995–2006).*

Mckauley et al. (2007) Diabetes Care 30:1539-1543

Effects of fatness on glucose and HbA1c among healthy adults

Variable	Male			Female		
	1st Group (N:161)	2nd Group (N:168)	3rd Group (N:159)	1st Group (N:169)	2nd Group (N:179)	3rd Group (N:171)
	Under 23.6	23.7~25.7	Up 25.8	Under 21.4	21.5~24.0	Up 24.1
Height(cm)	170.21±.40	170.11±.39	169.77±.40	158.85±.42	157.94±.40	158.95±.42
Weight(kg)	62.94±.57	71.62±.56*	79.77±.57 *#	50.46±.45	56.64±.43*	66.90±.45*#
Waist(cm)	77.56±.38	84.99±.37*	90.45±.38 *#	67.78±.38	72.96±.36*	82.25±.38*#
SBP (mmHg)	121.43±.92	124.82±.90*	128.08±.92 *#	116.90±1.02	119.89±.97*	126.49±1.02*#
DBP (mmHg)	74.68±.64	77.74±.66	80.22±.67	69.99±.72	71.67±.68	74.95±.72*#
Glucose(mg/dl)	104.17±1,88	102.89±1.84	106.12±1.89	91.89±1.13	95.87±1.07*	97.93±1.13*
HbA1C(mg/dl)	5.82±.07	5.70±.06	5.81±.07	5.50±.04	5.60±.04	5.63±.04*
TC (mg/dl)	183.30±2.51	189.70±2.45	198.42±2.52 *#	189.74±2.54	193.08±2.39	193.29±2.53
TG (mg/dl)	128.02±7.43	145.96±7.25	187.15±7.43 *#	96.00±5.02	104.81±4.75	126.45±5.00*#
LDL-C (mg/dl)	113.52±2.28	122.23±2.23*	129.06±2.28 *#	113.96±2.31	120.92±2.18*	121.78±2.30*
HDL-C (mg/dl)	49.17±.84	45.01±.82*	42.67±.84 *#	57.34±.94	53.15±.89*	50.06±.94*#

본 연구는 경기도 소재 M 병원에 내원한 건강검진 환자 1020명의 건강검진데이타와 체력 측정데이타를 분석한 연구임. Jeon et al. 2010 Unpublished Data

Effects of fatness on glucose and HbA1c among healthy adults

Variable	Male			Female		
	1st Group (N:161) Under 23.6	2nd Group (N:168) 23.7~25.7	3rd Group (N:159) Up 25.8	1st Group (N:169) Under 21.4	2nd Group (N:179) 21.5~24.0	3rd Group (N:171) Up 24.1
Height(cm)	170.21±.40	170.11±.39	169.77±.40	158.85±.42	157.94±.40	158.95±.42
Weight(kg)	62.94±.57	71.62±.56*	79.77±.57 *#	50.46±.45	56.64±.43*	66.90±.45*#
Waist(cm)	77.56±.38	84.99±.37*	90.45±.38 *#	67.78±.38	72.96±.36*	82.25±.38*#
SBP (mmHg)	121.43±.92	124.82±.90*	128.08±.92 *#	116.90±1.02	119.89±.97*	126.49±1.02*#
DBP (mmHg)	74.68±.64	77.74±.66	80.22±.67	69.99±.72	71.67±.68	74.95±.72*#
Glucose(mg/dl)	**104.17±1,88**	**102.89±1.84**	**106.12±1.89**	**91.89±1.13**	**95.87±1.07***	**97.93±1.13***
HbA1C(mg/dl)	**5.82±.07**	**5.70±.06**	**5.81±.07**	**5.50±.04**	**5.60±.04**	**5.63±.04***
TC (mg/dl)	183.30±2.51	189.70±2.45	198.42±2.52 *#	189.74±2.54	193.08±2.39	193.29±2.53
TG (mg/dl)	128.02±7.43	145.96±7.25	187.15±7.43 *#	96.00±5.02	104.81±4.75	126.45±5.00*#
LDL-C (mg/dl)	113.52±2.28	122.23±2.23*	129.06±2.28 *#	113.96±2.31	120.92±2.18*	121.78±2.30*
HDL-C (mg/dl)	49.17±.84	45.01±.82*	42.67±.84 *#	57.34±.94	53.15±.89*	50.06±.94*#

본 연구는 경기도 소재 M 병원에 내원한 건강검진 환자 1020명의 건강검진데이타와 체력 측정데이타를 분석한 연구임. Jeon et al. 2010 Unpublished Data

Effects of fitness on glucose and HbA1c among healthy adults

Variables	Male			Female		
	1st Group (N:164) Up 94	2nd Group (N:160) 83~93	3rd Group (N:162) under 82	1st Group (N:174) Up 98	2nd Group (N:172) 87~97	3rd Group (N:169) Under 86
Height(cm)	170.21±.40	170.13±.40	169.81±.40	157.±.41	158.47±.41	158.29±.42
Weight(kg)	71.39±.47	71.90±.47	70.97±.47	57.75±.31	58.18±.30	58.04±.31
Waist(cm)	85.02±.28	84.33±.29	83.66±.29*	74.34±.27	74.30±.27	74.16±.28
SBP (mmHg)	126.28±.91	123.59±.92	125.22±.91	122.49±.96	120.01±.95	119.97±.99
DBP (mmHg)	78.18±.66	76.97±.66*	76.41±.66*	73.54±.70	71.20±.69*	71.53±.72*
Glucose (mg/dl)	111.21±1.83	102.31±1.85*	99.60±1.84*	97.08±1.10	94.50±1.09	94.14±1.13
HbA1C(mg/dl)	6.03±.06	5.72±.06*	5.58±.06*	5.60±.04	5.59±.04	5.53±.04
TC (mg/dl)	192.33±2.51	190.94±2.54	188.01±2.52	196.15±2.46	191.47±2.44	188.50±2.52*
TG (mg/dl)	157.29±7.39	162.14±7.35	140.90±7.34#	106.66±4.87	114.51±4.80	104.22±4.99
LDL-C (mg/dl)	124.34±2.30	122.45±2.29	118.34±2.29	122.52±2.26	117.99±2.22	116.21±2..31
HDL-C (mg/dl)	44.41±.83	44.43±.82	48.12±.82*#	54.40±.92	53.40±.91	53.02±.94

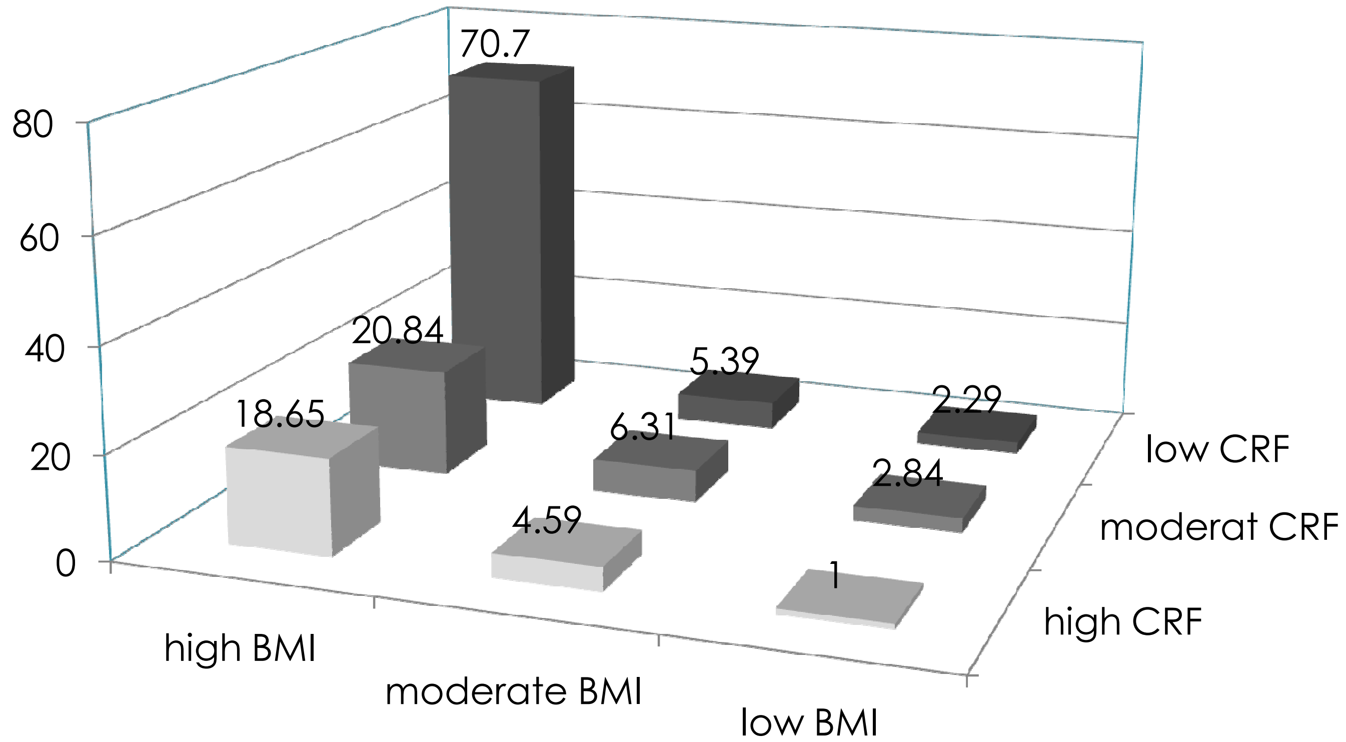
본 연구는 경기도 소재 M 병원에 내원한 건강검진 환자 1020명의 건강검진데이타와 체력 측정데이타를 분석한 연구임. Jeon et al. 2010 Unpublished Data

Effects of fitness on glucose and HbA1c among healthy adults

Variables	Male			Female		
	1st Group (N:164) Up 94	2nd Group (N:160) 83~93	3rd Group (N:162) under 82	1st Group (N:174) Up 98	2nd Group (N:172) 87~97	3rd Group (N:169) Under 86
Height(cm)	170.21±.40	170.13±.40	169.81±.40	157.±.41	158.47±.41	158.29±.42
Weight(kg)	71.39±.47	71.90±.47	70.97±.47	57.75±.31	58.18±.30	58.04±.31
Waist(cm)	85.02±.28	84.33±.29	83.66±.29*	74.34±.27	74.30±.27	74.16±.28
SBP (mmHg)	126.28±.91	123.59±.92	125.22±.91	122.49±.96	120.01±.95	119.97±.99
DBP (mmHg)	78.18±.66	76.97±.66*	76.41±.66*	73.54±.70	71.20±.69*	71.53±.72*
Glucose (mg/dl)	**111.21±1.83**	**102.31±1.85***	**99.60±1.84***	**97.08±1.10**	**94.50±1.09**	**94.14±1.13**
HbA1C(mg/dl)	**6.03±.06**	**5.72±.06***	**5.58±.06***	**5.60±.04**	**5.59±.04**	**5.53±.04**
TC (mg/dl)	192.33±2.51	190.94±2.54	188.01±2.52	196.15±2.46	191.47±2.44	188.50±2.52*
TG (mg/dl)	157.29±7.39	162.14±7.35	140.90±7.34#	106.66±4.87	114.51±4.80	104.22±4.99
LDL-C (mg/dl)	124.34±2.30	122.45±2.29	118.34±2.29	122.52±2.26	117.99±2.22	116.21±2..31
HDL-C (mg/dl)	44.41±.83	44.43±.82	48.12±.82*#	54.40±.92	53.40±.91	53.02±.94

본 연구는 경기도 소재 M 병원에 내원한 건강검진 환자 1020명의 건강검진데이타와 체력 측정데이타를 분석한 연구임. Jeon et al. 2010 Unpublished Data

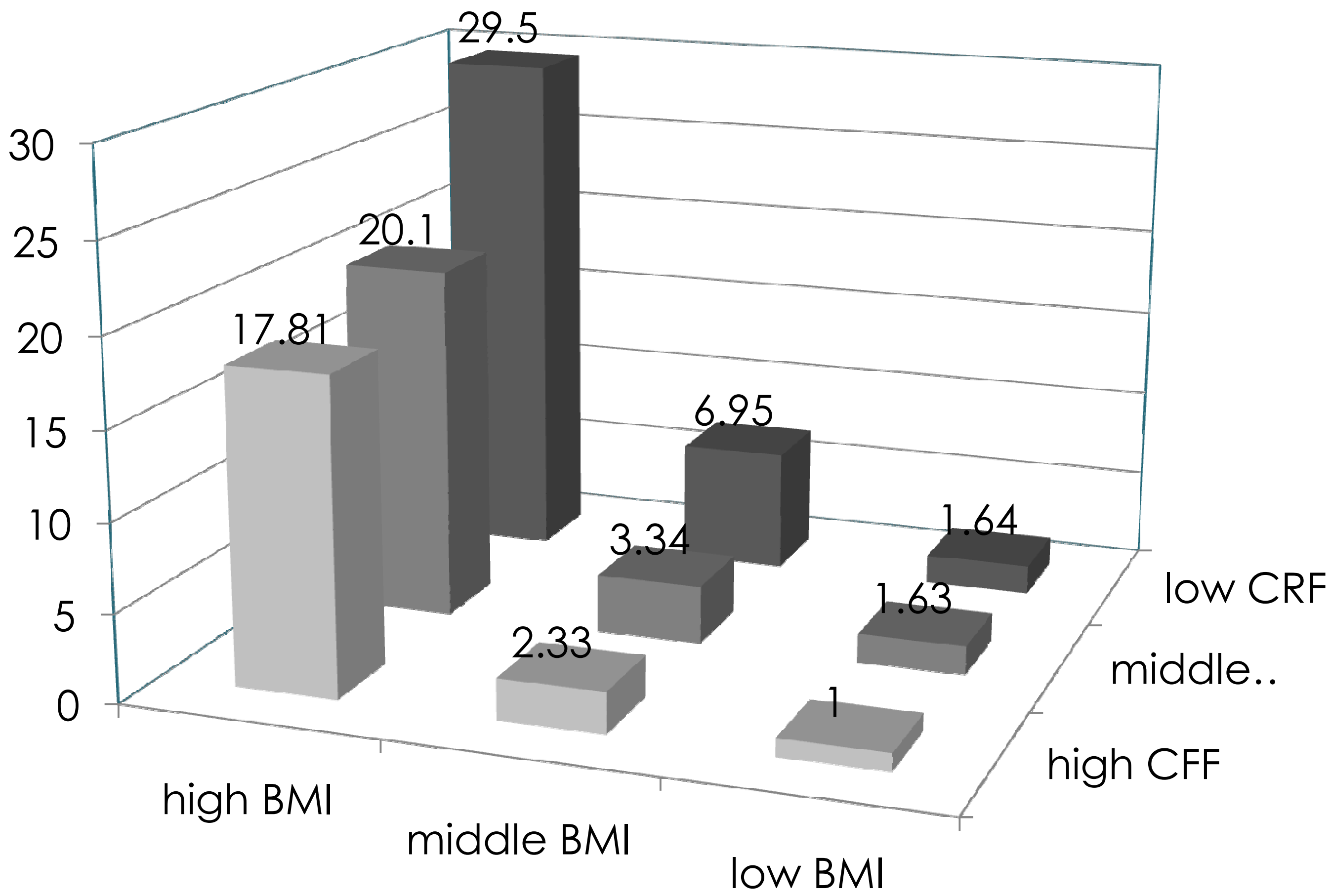
Relative risk of Metabolic Syndrome among Korean male adults according to their fatness and fitness



CRF: Cardio-respiratory Fitness, Fitness and BMI were stratified into tertile (33.3%)

Jeon et al. 2010 unpublished data

Relative risk of Metabolic Syndrome among Korean Female adults according to their fatness and fitness



CRF: Cardio-respiratory Fitness, Fitness and BMI were stratified into tertile (33.3%)

Jeon et al. 2009 unpublished data

Effects of fatness during high school on metabolic disease risk factors during adulthood

Table 4. Relative risk for the high level of blood pressure, glucose, total cholesterol and being obese in adulthood across the level of body index during adolescence

	1st group	2nd group	3rd group	4th group	5th group
Males					
No.	288	743	1,722	339	245
FG (≥ 110)	1.00	1.01 (0.62 to 1.63)	1.04 (0.67 to 1.62)	1.29 (0.76 to 2.17)	**2.26 (1.35 to 3.79)**
BP (SBP ≥ 130 or DBP ≥ 85)	1.00	0.94 (0.70 to 1.26)	1.14 (0.87 to 1.49)	**1.56 (1.28 to 2.15)**	**1.91 (1.35 to 2.70)**
TC (≥ 200)	1.00	**1.38 (1.04 to 1.84)**	**1.39 (1.07 to 1.81)**	1.32 (0.96 to 1.82)	**1.44 (1.02 to 2.02)**
BMI (≥ 25)	1.00	1.16 (0.83 to 1.61)	**2.95 (2.19 to 3.99)**	**8.96 (6.23 to 12.88)**	**18.96 (12.25 to 29.36)**
Females					
No.	53	102	292	104	85
FG (≥ 110)	1.00	0.95 (0.23 to 3.93)	1.26 (0.36 to 4.41)	0.38 (0.06 to 2.34)	1.98 (0.50 to 7.85)
BP (SBP ≥ 130 or DBP ≥ 85)	1.00	0.76 (0.31 to 1.86)	0.71 (0.32 to 1.57)	0.90 (0.36 to 2.24)	1.76 (0.73 to 4.26)
TC (≥ 200)	1.00	0.86 (0.43 to 1.74)	0.80 (0.43 to 1.50)	1.07 (0.52 to 2.20)	1.30 (0.62 to 2.71)
BMI (≥ 25)	1.00	2.22 (0.46 to 10.65)	**4.78 (1.12 to 20.31)**	**12.58 (2.87 to 55.16)**	**18.65 (4.23 to 82.35)**

Data presented as the relative risk (95% confidence interval). 1st group, most lean; 5th group, most fat.
FG, fasting glucose BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; BMI, body mass index

본 연구는 고등학교 시기의 비만도와 체력이 성인기 비만도와 만성질환에 미치는 영향을 분석한 연구로서 총 3993명의 데이터를 분석하였으며, 22년 Follow up 데이터 이다. Jekal et al. 2010 34:1-9 Korean Diabetes Journal

Effects of Fitness during high school on metabolic disease risk factors during adulthood

Table 5. Metabolic parameters in adulthood across the level of physical fitness during adolescence

	1st group	2nd group	3rd group	*P* value
Males				
No.	883	1,972	471	
FG (mg/dL)	94.04 ± 22.77	95.11 ± 23.80	93.18 ± 22.01	0.2021
SBP (mm Hg)	122.34 ± 12.98	122.41 ± 13.13	123.34 ± 14.66	0.3486
DBP (mm Hg)	77.84 ± 9.51	77.79 ± 9.88	78.84 ± 10.28	0.1060
TC (mg/dL)	199.84 ± 36.11	198.93 ± 34.55	199.33 ± 35.85	0.8140
BMI (kg/m^2)	24.92 ± 2.81	24.60 ± 2.94[a]	25.36 ± 3.57[a,b]	< 0.0001
Females				
No.	208	377	51	
FG (mg/dL)	88.52 ± 11.60	89.38 ± 12.72	98.37 ± 37.12[a,b]	0.0003
SBP (mm Hg)	110.64 ± 11.68	113.66 ± 12.75[a]	115.49 ± 13.81[a]	0.0059
DBP (mm Hg)	69.85 ± 8.45	71.92 ± 8.93a	72.88 ± 10.35	0.0117
TC (mg/dL)	181.32 ± 30.81	182.97 ± 31.03	195.29 ± 33.13[a,b]	0.0150
BMI (kg/m^2)	21.83 ± 2.91	22.49 ± 2.89[a]	23.38 ± 3.53[a]	0.0012

Data presented as the mean ± standard deviation. 1st group, most fit; 3rd group, least fit.
FG, fasting glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; BMI, body mass index.
[a]Significantly different from 1st group, [b]Significantly different from 2nd group.

본 연구는 고등학교 시기의 비만도와 체력이 성인기 비만도와 만성질환에 미치는 영향을 분석한 연구로서 총 3993명의 데이터를 분석하였으며, 22년 Follow up 데이터 이다. Jekal et al. 2010 34:1-9 Korean Diabetes Journal

Effects of Fitness during high school on metabolic disease risk factors during adulthood

	1st group	2nd group	3rd group
Males			
No.	883	1,972	471
FG (≥ 110)	1.00	1.02 (0.78 to 1.32)	0.76 (0.51 to 1.12)
BP (SBP ≥ 130 or DBP ≥ 85)	1.00	1.03 (0.87 to 1.21)	1.15 (0.92 to 1.45)
TC (≥ 200)	1.00	0.93 (0.80 to 1.10)	0.91 (0.73 to 1.14)
BMI (≥ 25)	1.00	0.87 (0.74 to 1.02)	**1.30 (1.04 to 1.63)**
Females			
No.	208	377	51
FG (≥ 110)	1.00	1.69 (0.74 to 3.89)	**3.11 (1.00 to 9.65)**
BP (SBP ≥ 130 or DBP ≥ 85)	1.00	1.52 (0.89 to 2.58)	2.09 (0.92 to 4.72)
TC (≥ 200)	1.00	1.01 (0.69 to 1.49)	1.46 (0.76 to 2.83)
BMI (≥ 25)	1.00	1.27 (0.79 to 2.05)	**2.36 (1.15 to 4.86)**

본 연구는 고등학교 시기의 비만도와 체력이 성인기 비만도와 만성질환에 미치는 영향을 분석한 연구로서 총 3993명의 데이터를 분석하였으며, 22년 Follow up 데이터 이다. Jekal et al. 2010 34:1-9 Korean Diabetes Journal

Effects of Fitness during high school on metabolic disease risk factors during adulthood

	Low Fat		High Fat	
RR (95%CI)	**High Fit**	**Low Fit**	**High Fit**	**Low Fit**
BP (SBP, 130≧ DBP, 85≧)	1.00	0.87 (0.61-1.24)	1.09 (0.26-4.65)	2.12 (0.70-6.46)
Glucose (110≧)	1.00	1.37 (0.81-2.31)	1.32 (0.16-11.09)	**4.11 (1.19-14.14)**
MS	1.00	0.92 (0.60-1.41)	0.60 (0.07-4.98)	**3.60 (1.17-11.12)**

본 연구는 고등학교 시기의 비만도와 체력이 성인기 비만도와 만성질환에 미치는 영향을 분석한 연구로서 총 3993명의 데이터를 분석하였으며, 22년 Follow up 데이터 이다. Jeon et al. 2010 Unpublished Data

Inha University 당뇨병센타 연구 (Pilot Data)

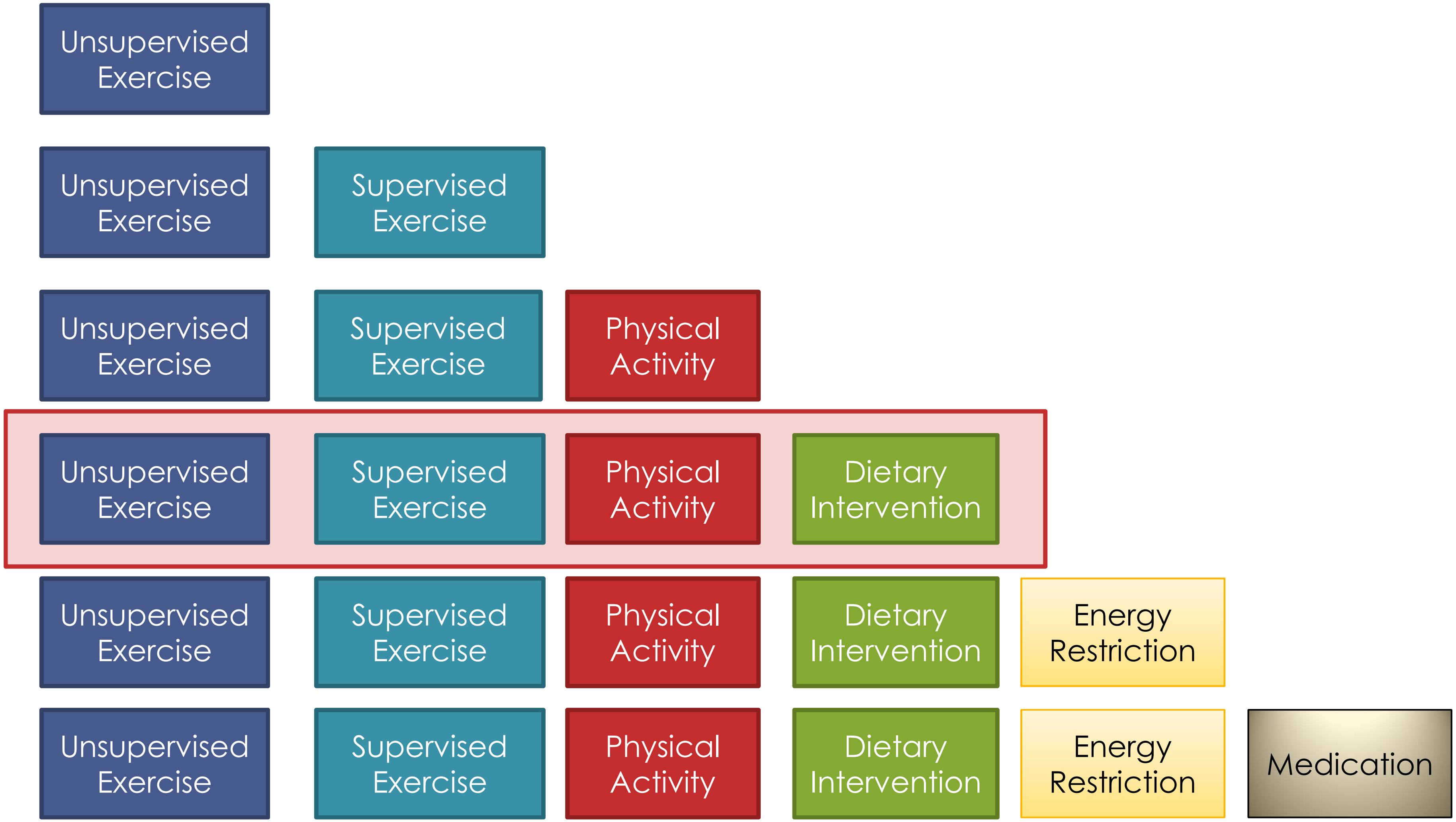
Association between cardiorespiratory fitness and metabolic parameters

	Model 1.	Model 2.	Model 3.
Glucose	-.558*	-.496*	-.360
HbA1C	-.652*	-.594*	-.567*
Insulin	-.202	-.259	-.227
HOMA	-.252	.219	-.258
LDL-C	-.228	-.500*	-.306
HDL-C	.366	.329	.446
TG	.196	.093	-.086
ABI R	.246	.428	.129
ABI L	-.479*	-.484*	-.366
PWV L	.482*	.505*	.382
PWV R	-.126	-.059	.064

Model 1. Gender controlled, Model 2. Gender and age controlled, Model 3. Gender, age, and BMI controlled

본 연구는 현재 인하대학교 당뇨병 센터에서 12**주 운동프로그램의 효과 분석 연구에 참여하고 있는 환자** 33**명의 결과를 분석한 결과임.**

Intervention Strategy (Inha University)



Subjects Characteristics

	Exercise (N=13)	Control (N=8)
Age (year)	49.90±7.80	48.41±8.14
Height (cm)	165.91±9.70	164.65±9.41
Weight (kg)	77.86±14.61	76.33±11.43
BMI (kg/m^2)	28.10±3.31	28.12±3.41
Percent fat (%)	32.21±5.71	32.95±7.00

Intervention program (Pilot data)

	Intervention program	
	Supervised exercise	Unsupervised exercise
Type	Core, Circuit Resistance and Aerobic Exercise	Aerobic Exercise
Duration	12 week	12 week
Frequency	3 time/week	2-3 time/week
Intensity	50%10RM, 15~20 repetition, 3 sets	60 % of VO2peak
Time	Warm up /Core exercise: 15~20min Circuit exercise : 30 min Cool down : 5~10 min	30~40 min

Effects of exercise training (N=13)

	0 week	6week	12week	12-0 diff	P-value
Body weight (kg)	77.86±17.54	76.04±13.88*	74.66±16.62**	-3.20±2.34	**< .001**
BMI (kg/m^2)	28.15±3.67	27.46±3.15	27.01±3.67*	-1.14±0.72	**< .001**
Muscle mass(kg)	51.05±12.31	52.12±11.39*	51.55±12.46	+0.50±0.94	.081
WC (cm)	91.15±10.07	88.31±8.60*	85.62±9.23**	-5.54±3.99	**< .001**
HC (cm)	99.54±6.23	97.69±5.17*	96.54±5.78*	-3.00±3.58	**.011**
SBP (mmHg)	127.85±16.61	116.52±12.4*	113.77±12.99*	-14.08±7.85	**< .001**
DBP (mmHg)	81.85±11.34	74.29±9.17*	73.46±8.96*	-8.38±0.94	**.001**

Effects of exercise on body composition (DEXA) (N=13)

	0 week	6week	12week	12-0 diff	P-value
Fat mass (kg)	24.55±5.71	21.52±5.88	21.33±5.79	-3.23±2.67	**.002**
Muscle mass (kg)	51.05±12.31	52.12±11.39	51.55±12.46	+0.50±0.94	.081
Percent fat(%)	32.19±3.71	29.77±6.10	28.99±5.04	-3.20±2.63	**.001**
Abdominal fat (%)	41.95±3.05	37.49±6.30	37.82±5.29	-4.12±4.37	**.005**

Effects of exercise training on musculoskeletal fitness

	0 week	6week	12week	12-0 diff	P-value
Dumbbell Press(kg)	9.58±6.30	12.24±7.02	15.50±14.86	+5.92±9.58	**< .001**
Lateral Raise(kg)	4.00±1.65	5.71±3.07	6.33±3.31	+2.33±2.31	**.004**
Leg Extension(kg)	48.33±25.61	59.51±26.25	65.42±32.22	+17.08±16.85	**< .001**
Pull Down(kg)	35.83±14.90	42.38±16.33	48.33±19.46	+12.50±10.77	**.001**
Triceps Extension (kg)	5.79±3.04	7.52±4.26	8.42±4.29	+2.63±2.04	**< .001**
Biceps Curl(kg)	6.67±2.81	8.76±3.58	8.92±4.34	+2.25±1.91	**< .001**
Squat(kg)	24.10±23.22	34.76±22.50	41.14±30.89	+17.05±11.23	**< .001**
Push Up(회)	12.83±10.36	21.25±17.40	32.75±16.21	+19.92±12.92	**.037**
Sit Up(회)	12.27±14.18	19.45±16.99	19.91±19.28	+7.64±6.56	**< .001**
VO2max	30.03±5.07	30.90±5.48	31.96±5.93	+1.92±2.10	**< .001**

Effects of exercise training on metabolic parameters

	0 week	6week	12week	12-0 diff	P-value
Glucose(mg/dl)	134.57±17.93	126.95±21.76	117.00±31.29	-17.57±30.87	**.05**
HbA1c	7.51±0.71	7.01±0.75	6.69±0.60	-0.83±0.41	**< .001**
TG(mg/dl)	167.14±99.57	110.19±43.32	126.36±65.80	-40.79±82.57	.087
TC(mg/dl)	158.93±27.97	148.81±23.13	153.43±28.24	-5.50±19.27	.305
HDL(mg/dl)	47.71±8.70	45.48±9.14	47.50±10.54	-0.21±6.91	.909
LDL(mg/dl)	85.38±19.67	84.00±22.00	84.00±27.56	-1.38±20.19	.809

Effects of exercise on liver enzyme

	0 week	6week	12week	12-0 diff	P-value
AST(units/L)	23.43±12.57	22.81±7.97	21.00±4.57	-2.43±9.94	.377
ALT(units/L)	32.43±16.35	29.05±13.56	22.71±8.44	-9.71±12.14	**.010**
GGT(units/L)	41.36±29.00	27.67±18.43	25.93±18.86	-15.43±17.99	**.007**

On going research

- Mechanism of exercise associated improvement in glucose control and type 2 diabetes
  - Adipocytokine (NF-kb, Vaspin), liver insulin sensitivity (Fatty liver, Pentraxin-3 etc)
  - Visceral fat vs Fatty liver
- Effects of musculoskeletal fitness on type 2 diabetes and glucose control
- Finding minimal fitness levels for Korean adults
- Development of easy, reliable, and valid fitness measurements

운동은 자율적이어야 한다. 즐겁게 하자

E. Narath et al. / Experimental Gerontology 36 (2001) 1699–1711

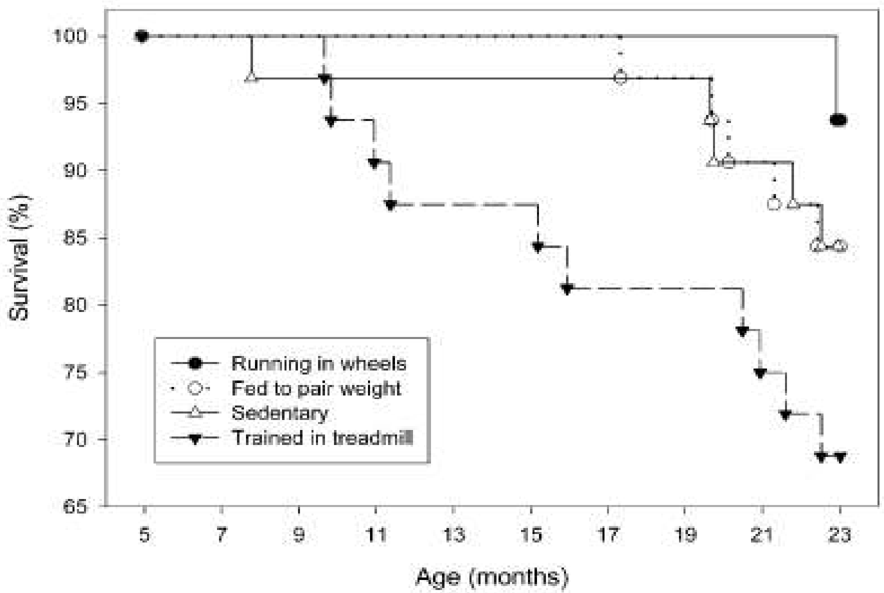


Fig. 2. Survival of animals in the experimental groups.

운동이 쥐의 수명에 미치는 영향을 조사한 연구에서 강제로 운동시킨 (Treadmill) 쥐는 운동을 하지 않은 쥐보다 더 수명이 짧았다. 반면 자율적으로 운동한 쥐는 운동을 하지 않은 쥐 보다 수명이 길었다.

Acknowledgement

- 인하대학병원 당뇨병센타: 남문석, 김소헌
- 연세대학교 세브란스 내분비 내과: 이현철, 강은석
- 연세대학교 보건대학원 : 지선하, 윤지은
- 연세대학교 간호대학: 오의금, 추상희
- 연세대학교 스포츠의학 연구실: 제갈윤석, 김은성, 박지혜, 이미경, 이승환, 안기용, 나루세 마사요, 김지영, 김동일, 문진영, 이동훈