循環器危険因子をもたない低リスク者の総死亡及び死因別死亡リスク

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研究の背景と目的

近年、諸外国では循環器疾患の主要な危険因子（高血圧、高脂血症、喫煙、糖尿病）を1つも持たない集団をLow risk groupとしてとらえ、この集団の長期予後が危険因子を1つ以上持つ集団と比較して低いことなどを示した報告が少なからず見受けられるがわが国ではまだ報告されていない[1-7]。 わが国は世界有数の長寿国であるが乳児死亡率の低下以外に、循環器疾患死亡率が低いことも長寿と関連していると思われる[8,9]。冠動脈疾患死亡率はアメリカの1/3であり、脳卒中死亡率はここ数十年激減し欧米と同程度である[8-12]。このようにわが国では循環器疾患の疾病構造が欧米とは異なるためLow risk groupの条件も異なる可能性がありその意味で独自の検討が必要である。そこでLow risk groupがわが国においても良好な長期予後を有するかどうか、Low risk groupの割合が欧米と比べ違いがあるかどうか、及び循環器疾患の古典的危険因子の総死亡に与える影響を人口寄与危険割合を求めて検討を加えた。

方法

1980年に実施された循環器疾患基礎調査の対象者10546人のうち、重要なデータの欠落したもの、追跡不能者、心筋梗塞・脳梗塞・狭心症の既往のある者を除外した年齢30-69歳の男女合わせて8339人（男3658人、女4681人）を19年間追跡したデータ（NIPPONDATA 80）を解析した[13-16]。ベースライン調査では5分間安静時血圧、身長・体重、BMIの算出、自記式質問表による飲酒・喫煙・現在の身体状況・既往歴の聴取、血液データ（随時あるいは食後5時間以上の血糖値、総コレステロールなど）の採取、心電図検査が実施された。対象者はLow risk groupとOthersの2群に分けられた。Low risk groupの基準は次の①から④のように定め、これら全てを満たすものをLow risk groupとし、危険因子を少なくとも1個以上持つ群をOthersとした。

血圧；SBP（収縮期血圧）＜120mmHg、DBP（拡張期血圧）＜80mmHg かつ降圧薬の服用なし。
血糖；随時血糖値<200mg/dl または空腹時（食後最低5時間以上）血糖値＜126mg/dl、かつ糖尿病歴なし。
血清コレステロール；160mg/dl <TC（血清コレステロール値）＜240mg/dl。
現在非喫煙。
血圧は JNC7 の正常血圧の基準に従った[17]。コレステロールの基準は、160mg/dl 未満の低コレステロール血症は脳出血の危険を増すこと、及び 200-240mg/dl のコレステロール値は循環器疾患の危険の上昇とわが国では関連しないことから③のように定めた[13、18-19]。そして Others と比較した Low risk group の総死亡および主要な死因に対する年齢・性・BMI・飲酒で調整したハザード比（HR）を求めた。
さらに危険因子の集団内の頻度と総死亡に対する各因子のハザード比から計算された人口寄与危険割合〔リスク群の死亡数の割合＊（多変量調整 HR－1）/多変量調整 HR 総死亡〕を求めた[20]。

結果

表1に各群のベースライン調査時の特徴を示した。Low risk group は全体の 9.4%であり女性が 86%を占めた。年齢、BMI,収縮期血圧、拡張期血圧、血糖値は両群で著明に差が認められた。総死亡および主要な死因に対する死亡率および Others を基準値 1.0 としたときの Low risk group の各死因に対するハザード比を表2に示した。年齢・性・BMI・飲酒で調整したハザード比（HR）は循環器死亡では 0.33 （95%CI；0.15-0.74）、総死亡では 0.63 （95%CI； 0.46-0.88）であった。また、Low risk group では脳卒中死亡は1人しか観察されず（0.1/千人年）、Others の 154（1.1/千人年）に比較し著明に少なかった。癌死亡については Low risk group のハザード比は 0.90 で Others と比較して若干の死亡率の低下が認められたが有意ではなかった。また、総死亡に与える各危険因子の寄与の程度は表3のようであった。総死亡に占める各リスク群の死亡数の割合は非至適血圧(SBP＜120mmHg かつ DBP＜80mmHg)がもっとも高く全体の 91.8%を占め、喫煙、非至適コレステロール（160mg/dl <TC＜240mg/dl）がそれぞれ 46.6%、30.1%でこれに続いた。糖尿病の頻度は 9.4%でもっとも少なかった。これに対してハザード比は糖尿病が 1.81（CI:1.48-2.22）ともっとも高く、喫煙、非至適血圧、非至適コレステロールがそれぞれ 1.51（CI:1.31-1.74）、1.40（CI:1.13-1.74）、1.20（CI:1.06-1.37）であった。結果として人口寄与危険割合は非至適血圧が 26.2%で最も高く、以下喫煙 15.7%、非至適コレステロール 5.1%,糖尿病 4.2%の順であった。また、男女別で解析したところ男性は非至適血圧、喫煙、非至適コレステロール、糖尿病の順に 20.8%, 20.5%, 5.0%, 4.5%, 女性は同順で 31.8%, 6.0%, 5.6%, 3.2%であった。

考察

わが国の循環器疾患の Low risk group の死亡率は循環器疾患死亡だけでなく総死亡においても Others（その他の群）と比べて低かった。また、各危険因子の中で総死亡に最も影響したのは非至適血圧であり、喫煙がその次であった。

欧米の先行研究の中の、16 年間追跡の MRFIT 研究と 22 年間追跡の CHA 研究を合わせた 5 コホートを解析した研究では Low risk は血圧 120/80mmHg 以下、コレステロール< 200mg/dl、非喫煙、糖尿病・心筋梗塞既往なしで定義された[1]。この研究では Low risk group は全体の 4.8-9.9%、総死亡の HR は 0.42-0.60、CVD 死亡の HR は 0.15-0.28 であり、それと比べると本研究の Low risk group の死亡率の低下の程度はやや緩やかであった。これについて以下の可能性が考慮された。わが国の循環器疾患死亡の総死亡比は男性 27.5%、女性 35.3%（2000 年、WHO Health statistics)、USA では男性 37.2%、女性 41.1%である[9]。つまりわが国では循環器疾患死亡が USA に比べ少ないので Low risk group の影響も少なかった可能性がある。また、わが国の循環器疾患の中ではこの数十年間で激減したとはいえ脳卒中の占める割合が高く、若年でも発症し死亡する冠動脈疾患が少ないために追跡期間中に与える影響が小さかったのではないか[8]。さらに当時男性の喫煙率は 70%を超えていたので喫煙していない Low risk group の男性の中に結核や肺疾患など健康に問題がありそのために喫煙できなかったもともと弱いものが含まれており効果が薄まった可能性も否定できないと思われる。

また、Low risk group の割合も欧米と比較して差は認められず、Low risk group が多いことをわが国で循環器疾患死亡が比較的に低いことの説明にはできなかった。このことから、古典的危険因子以外の因子の関与の可能性が示唆された。最近の知見では、日米間比較研究で古典的リスクファクターに相違がない男性集団で冠動脈石灰化の程度に違いがあるとか EPA の摂取量の違いと HDL(high density lipoprotein) 値の違いなどを検討したものがあり今後の新たな危険因子あるいは保護的要因の解明が待たれる[14,21-23]。

人口寄与危険割合については男女ともに有病率の高い非至適血圧の与える影響が最大であったが、ハザード比は糖尿病が最も高く、有病率が 1980 年当時に比較し 2003 年では約 2 倍に増加していることを考慮すれば今後は糖尿病の与える影響が看過できないと思われる。また、喫煙については当時の喫煙率の男女差（男性 64.8%、女性 8.8%）が影響し、男性では非至適血圧とほぼ並ぶ 20%の影響が認められ、女性では非至適血圧の影響が有意に高く 30%以上を占めた。

結論

わが国でも低リスク群は他群に比べ循環器疾患死亡だけでなく総死亡においても危険度の低下が確認された。さらに総死亡に与える影響は血圧を適正に保つことが最も大きく、非喫煙がその次であった。これら危険因子を持たない低リスク群の増加が今後も一層望まれる。

表 1. Low risk group と Others に分けた 30 歳以上 69 歳以下の対象者 8339 人（男性 3658 人、女性 4681 人）のベースライン調査時の特徴、NIPPON DATA80

	†Low risk group	Others	P
N (%)	784 (9.4)	7555 (90.6)	
年齢 (年)	43.0±9.6	48.5±11	<0.01
男性 (%)	13.9	47.0	<0.01
BMI (kg/m^2)	21.9±2.9	22.9±3.1	<0.01
SBP (mmHg)	109±6.7	137±20	<0.01
DBP (mmHg)	67.7±6.3	82.7±12	<0.01
TC (mg/dL)	190±20	189±35	NS
血糖 (mg/dL)	92.7±17	101±31	<0.01
喫煙 (%)	0	37.0	

表中の数字は平均±標準偏差, または頻度

†Low risk group の定義は文章中参照

P 値は t 検定または χ^2 検定、 NS, 有意差なし

BMI, body mass index; SBP, 収縮期血圧； DBP, 拡張期血圧； TC, 血清総コレステロール

表 2. 主な死因に関する死亡数と Low risk group と Others のハザード比 (95%CI) 男女総計, NIPPON DATA80, 1980-99

死因	†Low risk group (N=784)	Others (N=7555)
総死亡		
粗死亡率 (/TPY)	2.6	8.0
年齢調整 HR (95%CI)	0.65 (0.47-0.90)	1.00
*多変量調整 HR (95%CI)	0.63 (0.46-0.87)	1.00
循環器疾患死亡		
粗死亡率 (/TPY)	0.4	2.5
年齢調整 HR (95%CI)	0.33 (0.15-0.74)	1.00
*多変量調整 HR (95%CI)	0.33 (0.15-0.74)	1.00
癌死亡		
粗死亡率 (/TPY)	1.4	3.1
年齢調整 HR (95%CI)	0.89 (0.57-1.39)	1.00
*多変量調整 HR (95%CI)	0.90 (0.57-1.40)	1.00

CI, 信頼区間； TPY, 千人年； HR, ハザード比 (Others を基準)

*年齢、性、BMI、飲酒、喫煙で調整

†Low risk group の定義は文章中参照

表 3.　循環器疾患の危険因子の人口寄与危険割合、男女総計, NIPPON DATA80, 1980-99

危険因子		死亡数 (%)	†多変数調整 HR (95%CI)	人口寄与危険割合
全体				
血圧	至適血圧	94 (8.2%)	1.00	
	非至適血圧	1046 (91.8%)	1.40 (1.13-1.74)	26.2%
喫煙	非喫煙	609 (53.4%)	1.00	
	喫煙	531(46.6%)	1.51 (1.31-1.74)	15.7%
総コレステロール	至適	796 (69.9%)	1.00	
	非至適	344 (30.1%)	1.20 (1.06-1.37)	5.1%
糖尿病	非糖尿病	1032 (90.6%)	1.00	
	糖尿病	108 (9.4%)	1.81 (1.48-2.22)	4.2%
男性				
血圧	至適血圧	51 (7.7%)	1.00	
	非至適血圧	613 (92.3%)	1.29 (0.97-1.72)	20.8%
喫煙	非喫煙	199 (30.0%)	1.00	
	喫煙	465 (70.0%)	1.41 (1.19-1.67)	20.5%
総コレステロール	至適	456 (68.7%)	1.00	
	非至適	208 (31.3%)	1.17 (0.99-1.37)	4.5%
糖尿病	非糖尿病	590 (88.9%)	1.00	
	糖尿病	74 (11.1%)	1.82 (1.49-2.23)	5.0%
女性				
血圧	至適血圧	43 (9.0%)	1.00	
	非至適血圧	433 (91.0%)	1.54(1.11-2.12)	31.8%
喫煙	非喫煙	410 (86.1%)	1.00	
	喫煙	66 (13.9%)	1.76 (1.35-2.29)	6.0%
総コレステロール	至適	340 (71.4%)	1.00	
	非至適	136 (28.6%)	1.24 (1.02-1.51)	5.6%
糖尿病	非糖尿病	442 (92.9%)	1.00	
	糖尿病	34 (7.1%)	1.83 (1.29-2.60)	3.2%

各危険因子の基準は Low risk group の定義と同様。

日本人集団の飲酒に起因すると考えられる高血圧の割合；NIPPON DATA90 のベースライン調査による検討

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【 目的 】
飲酒は高血圧の原因であるが、日本人男性の平均的な飲酒量は米国、英国などの欧米先進国の男性と比べると多い。このため、日本人男性の飲酒習慣は日本人男性の高血圧にかなり影響を及ぼしている可能性がある。日本全国から無作為に選ばれた地域在住の高血圧者集団の中で飲酒に起因した高血圧者の割合を男女別に推定することを試みた。

【 方法 】
日本人男性 3,454 名、女性 4,808 名（ともに平均年齢は 53 歳）の飲酒習慣、血圧値などの情報が解析に利用された。ロジスティック回帰分析を用いて、高血圧に対する飲酒習慣のオッズ比が計算され、高血圧者集団の中で飲酒に起因したと考えられる高血圧者の割合が推定された。

【 結果 】
男性の全対象者の中で、飲酒習慣（現在飲酒している、またはかつて飲酒していたが断酒した）を有する者は 64.8%、高血圧（収縮期血圧 140mmHg 以上、拡張期血圧 90mmHg 以上、降圧剤服用中のいずれか）を有する者は 49.8%であった。女性の全対象者の中では、飲酒習慣を有する者は 7.6%、高血圧を有する者は 43.1%であった。高血圧に対する飲酒習慣のオッズ比（年齢、Body Mass Index を調整）は男性 1.96 (95%信頼区間, 1.67-2.29)、女性 1.54 (1.20-1.98)であった。そして、高血圧者集団の中で飲酒に起因したと考えられる高血圧者の割合は男性では 34.5% (95%信頼区間, 10.9%-51.9%)、女性では 2.6% (0.8%-5.8%)であった。同様にして、一日あたりの平均飲酒量毎に高血圧に対するオッズ比を計算したところ、表に示すとおり男女とも飲酒量が多いほどオッズ比が高くなる傾向を示した。男性の高血圧者集団の中で飲酒に起因したと考えられる高血圧者の割合約 34.5%の内訳は 1 合/日が 12.7%、2 合/日が 11.1%、3 合以上/日が 5.8%、断酒が 4.8%であった。一方、女性の高血圧者集団の中で飲酒に起因したと考えられる高血圧者の割合約 2.6%の内訳は 1 合/日が 1.8%、2 合以上/日が 0.7%、断酒が -0.1%であった。飲酒に起因したと考えられる高血圧者の中で、男女とも 1 合/日程度の飲酒習慣による者が多くの割合を占めていた。これは飲酒者の中で 1 合/日程度の者が最も多いためと考えられた。

【 結論 】日本人男性の飲酒習慣は日本人男性の高血圧に大きな影響を及ぼしている可能性がある。日本人男性の高血圧への公衆衛生的アプローチにおいて、飲酒習慣の適正化への啓

発は重要であると考えられる。但し、適度な飲酒習慣には虚血性心疾患や脳梗塞に対する予防的な効果があるため、その点も考慮する必要があるだろう。

表. 飲酒習慣(平均飲酒量)毎の高血圧者の頻度、高血圧に対する飲酒習慣のオッズ比と全高血圧者の中で飲酒が起因していると推測される高血圧者の割合 (NIPPON DATA90)

飲酒習慣	対象者数 (分布(%))	高血圧者数	高血圧頻度 (%)	オッズ比 * (95%信頼区間)	各飲酒習慣に起因した高血圧者の割合(%)
男性					
非飲酒	1,217 (35.2)	508	41.7	1.00	
1合/日	998 (28.9)	514	51.5	1.74 (1.45-2.10)	12.7
2合/日	694 (20.1)	371	53.5	2.06 (1.67-2.53)	11.1
3合以上/日	302 (8.7)	168	55.6	2.46 (1.86-3.25)	5.8
断酒	243 (7.0)	160	65.8	2.05 (1.49-2.81)	4.8
女性					
非飲酒	4,442 (92.4)	1,923	43.3	1.00	
1合/日	251 (5.2)	101	40.2	1.58 (1.17-2.14)	1.8
2合以上/日	63 (1.3)	30	47.6	2.09 (1.17-3.72)	0.7
断酒	52 (1.1)	20	38.5	0.94 (0.49-1.79)	-0.1

1合はアルコール23gに相当

* 年齢, Body Mass Indexを調整

【 研究成果の公表 】

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Original Article

The Proportion of Individuals with Alcohol-Induced Hypertension among Total Hypertensives in a General Japanese Population: NIPPON DATA90

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Japanese men consume more alcoholic beverages than men in many other developed countries. The high consumption rate of alcoholic beverages among Japanese men may contribute to the high prevalence of hypertension in Japan. In the present study, we calculated the odds ratio for hypertension in alcohol drinkers based on recent criteria using data from a nationwide survey conducted in Japan in 1990, and estimated, among total hypertensives in a general Japanese population, the percentage of hypertensives whose condition was due to alcohol consumption. Of 3,454 male participants, 64.8% were drinkers (1 *gou*/day, 28.9%; 2 *gou*/day, 20.1%; 3 *gou*/day or more, 8.7%; ex-drinkers, 7.0%) and 49.8% were hypertensive, whereas 7.6% of 4,808 female participants were drinkers (1 *gou*/day, 5.2%; 2 *gou*/day or more, 1.3%; ex-drinkers, 1.1%) and 43.1% were hypertensive (1 *gou*=23.0 g of alcohol). In both sexes, drinkers had a higher odds ratio for hypertension than never drinkers, and there was a significant dose-response relationship between the amount of alcohol consumed and the odds ratio for hypertension. Among all hypertensives, the percentage whose hypertension was due to alcohol consumption was 34.5% (95% confidence interval, 10.9%–51.9%) for men and 2.6% (0.8%–5.8%) for women. The corresponding proportion based on daily alcohol intake was 12.7% for 1 *gou*/day, 11.1% for 2 *gou*/day, 5.8% for 3 *gou*/day or more, and 4.8% for ex-drinkers in men, and 1.8% for 1 *gou*/day, 0.7% for 2 *gou*/day or more, and −0.1% for ex-drinkers in women. In conclusion, we found that a large percentage of the hypertensives in a general Japanese male population had alcohol-induced hypertension. (*Hypertens Res* 2007; 30: 663–668)

***Key Words*: alcohol drinking, hypertension, Japan**

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Introduction

Alcohol consumption has been associated with the development of hypertension (*1–10*), and Japanese men consume more alcoholic beverages than men in many other developed countries, including the United States and the United Kingdom (*11–15*). These facts suggest that the high consumption of alcoholic beverages among Japanese men may contribute to the high prevalence of hypertension in Japan (*12*, *16*). Thus, it is important to clarify the proportion of hypertensives in the general Japanese population whose hypertension was induced by alcohol. Although this percentage has been determined in previous studies (*17*), it has not been estimated since the recent establishment of new criteria for hypertension (systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg).

In the present study, we attempted to estimate the proportion of individuals with alcohol-induced hypertension among total hypertensives in a randomly selected Japanese population using the recently established criteria for hypertension.

Methods

Study Design and Participants

NIPPON DATA (National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged) is a series of cohort studies conducted by the National Survey on Circulatory Disorders, Japan. In the present study, we analyzed baseline data from NIPPON DATA90 (data from the Fourth National Survey on Circulatory Disorders, Japan in 1990); the details of this cohort study have been reported previously (*18–21*).

A total of 8,384 community residents (3,504 men and 4,880 women; ≥30 years old) from 300 randomly selected districts participated. The overall population aged 30 and over in all districts was 10,956 and the participation rate in this survey was 76.5%. Of the 8,384 participants, 122 were excluded because of missing information in the baseline survey. The remaining 8,262 participants (3,454 men and 4,808 women) were included in the analysis. Accordingly, the participants in the present study were thought to be representative of the Japanese population.

The present study was approved by the Institutional Review Board of Shiga University of Medical Science for Ethical Issues (No.12-18, 2000).

Examination

Public health nurses asked the participants about their alcohol consumption habits and classified them into the following five groups: never drinker, current daily drinker of 1 *gou*/day, 2 *gou*/day, or 3 *gou*/day or more, or ex-drinker. The *gou* is a traditional Japanese alcohol drinking unit, and 1 *gou* is equivalent to 180 mL of sake (Japanese rice wine), which contains 23.0 g of alcohol. Its alcohol content is roughly equivalent to 663 mL (1 bottle) of beer, 70 mL (two single shots) of whisky, or 110 mL (a half glass) of "shochu" (spirits made from barley, sweet potato, rice or any combination of these). In order to estimate the proportion of individuals with alcohol-induced hypertension among total hypertensives in the study population, male and female participants were classified into two categories, never drinkers and drinkers, with the latter category consisting of current drinkers and ex-drinkers. We included ex-drinkers in the drinker category because drinkers diagnosed with hypertension might have been advised to quit drinking alcohol. In addition to the above analysis, we estimated the proportion of individuals with alcohol-induced hypertension among total hypertensives by taking the quantity of alcohol consumed into consideration. In this analysis, male participants were classified into the following five categories: never drinker, 1 *gou*/day, 2 *gou*/day, 3 *gou*/day or more, and ex-drinker. Furthermore, female participants were classified into the following four categories: never drinker, 1 *gou*/day, 2 *gou*/day or more, and ex-drinker. A category of 3 *gou*/day or more was not used in women, because only 1.3% of the female participants were heavy drinkers (2 *gou*/day, $n=36$; 3 *gou*/day or more, $n=27$).

Baseline blood pressures were measured once by trained observers using a standard mercury sphygmomanometer on the right arm of seated participants after a sufficient period of rest. Information on the use of antihypertensive agents was also obtained by public health nurses. Referring to the Seventh Report of the Joint National Committee (*17*), hypertension was defined as a systolic blood pressure ≥140 mmHg, a diastolic blood pressure ≥90 mmHg, the use of antihypertensive agents, or any combination of these. Body mass index was calculated as weight (kg) divided by the square of height (m).

Statistical Analysis

The data were analyzed separately for men and women, because alcohol consumption habits are quite different between the sexes in Japan (*7*, *11*, *16*, *22*). Initially, one way analysis of variance or a χ^2 test was used to compare risk characteristics at baseline among the different alcohol-intake categories. Next, we calculated the prevalence of hypertension in each of two alcohol drinking habit categories (never drinkers and drinkers [including ex-drinkers]). A logistic regression model was used to calculate the odds ratio for hypertension in drinkers with never drinkers serving as a reference. Age and body mass index were included in the regression models as potential confounding variables. We estimated the percentage of individuals having alcohol-induced hypertension among total hypertensives—*i.e.*, the population attributable fraction—using the following equation: [prevalence of drinkers among hypertensives × (odds ratio − 1)]/odds ratio (*23*). The 95% confidence interval for the corresponding proportion was calculated using the formula pro-

Table 1. Baseline Risk Characteristics in 1990 of 8,262 Japanese Participants Based on Sex and Alcohol Drinking Habit: NIPPON DATA90

	Alcohol drinking habit				
	Never drinker	1 *gou*/day	2 *gou*/day (or more for women)	3 *gou*/day or more	Ex-drinker
Men					
Number of participants (*n* (%))	1,217 (35.2)	998 (28.9)	694 (20.1)	302 (8.7)	243 (7.0)
Age (years)*,‡	54.3±14.7	52.9±13.5	51.1±11.8	49.4±10.9	61.3±14.1
Body mass index (kg/m²)*,‡	22.8±3.1	22.9±2.9	23.2±2.9	23.5±3.1	22.7±3.3
Systolic blood pressure (mmHg)*,‡	134.8±20.0	138.4±19.9	139.0±19.0	141.0±20.1	141.8±21.1
Diastolic blood pressure (mmHg)*,‡	81.2±10.9	84.0±11.2	85.6±11.9	86.3±12.1	84.0±12.8
Use of antihypertensive agents (%)†,‡	9.9	14.1	13.5	9.6	24.3
Women					
Number of participants (*n* (%))	4,442 (92.4)	251 (5.2)	63 (1.3)		52 (1.1)
Age (years)*,‡	53.1±14.2	47.1±11.4	47.7±10.5		51.5±13.7
Body mass index (kg/m²)*	22.9±3.3	22.5±3.1	22.8±3.5		22.5±3.4
Systolic blood pressure (mmHg)*,‡	133.9±20.8	131.1±20.8	132.7±19.3		128.2±22.2
Diastolic blood pressure (mmHg)*	79.4±11.7	81.0±13.0	81.6±10.4		77.7±13.2
Use of antihypertensive agents (%)†	15.9	10.8	20.6		19.2

Values indicate the mean±SD or the % of participants in that category. One *gou* contains 23.0 g of alcohol. *Mean values were compared among the categories by one way analysis of variance. †Proportions were compared among the categories by a χ^2 test. ‡The difference among the alcohol drinking habit categories was statistically significant ($p<0.05$).

posed by Greenland (*24*). Finally, in order to investigate the corresponding proportion of individuals with alcohol-induced hypertension by daily intake of alcohol, we analyzed the data using the above equation after classifying the male and female participants into five and four categories, respectively, based on their habits of alcohol consumption.

The statistical analysis was performed using SPSS 14.0J for Windows (SPSS Japan Inc., Tokyo, Japan). p values were two-sided, and values of $p<0.05$ were considered statistically significant.

Results

The mean values or proportions of risk characteristics for male and female participants grouped according to their alcohol consumption habits are summarized in Table 1. Of the 3,454 male participants (mean age, 53.3 years old), 64.8% had a current or past alcohol consumption habit and 49.8% were hypertensive, whereas only 7.6% of the 4,808 female participants (mean age, 52.7 years old) had a drinking habit and 43.1% were hypertensive. For both sexes, the mean age was higher in never drinkers and ex-drinkers than in daily drinkers. For men, the mean body mass index was lower in never drinkers and ex-drinkers than in daily drinkers of 2 *gou*/day or more.

Male drinkers had a higher prevalence of hypertension compared to never drinkers (54.2% for drinkers *vs.* 41.7% for never drinkers), and we confirmed a significantly higher odds ratio for hypertension in drinkers after adjustment for age and body mass index (1.96; 95% confidence interval, 1.67–2.29). Although female drinkers had a somewhat lower prevalence of hypertension (41.3% for drinkers *vs.* 43.3% for never drinkers), we confirmed a significantly higher odds ratio for hypertension in drinkers after adjustment for the same confounding factors (1.54; 95% confidence interval, 1.20–1.98). The proportion of individuals with alcohol-induced hypertension among total hypertensives was estimated to be 34.5% (95% confidence interval, 10.9%–51.9%) in men and 2.6% (95% confidence interval, 0.8%–5.8%) in women (the results described above are not shown in Table 1).

There was a dose-response relationship between daily alcohol intake and the odds ratio for hypertension in both sexes (Table 2). Even the odds ratio for hypertension in daily drinkers who consumed 1 *gou*/day was significantly higher in both sexes. Table 2 shows the percentage of individuals with alcohol-induced hypertension among total hypertensives in each daily-intake category. The proportion of individuals with alcohol-induced hypertension was highest in daily drinkers of 1 *gou*/day in both sexes.

Discussion

In the present study, we found a large proportion of individuals with alcohol-induced hypertension among all hypertensive participants in a representative Japanese male population. Approximately one-third of male hypertensives—but only a few percent of female hypertensives—had hypertension due to alcohol consumption. There are prominent regional differences in alcohol consumption in Japan (*11*, *22*, *25*), which may affect the proportion of individuals with alcohol-induced

Table 2. Prevalence of Hypertension, Odds Ratio for Hypertension in Alcohol Drinkers, and Proportion of Individuals with Alcohol-Induced Hypertension among Total Hypertensives in 1990 Grouped by Sex and Alcohol Drinking Habit among 8,262 Participants: NIPPON DATA90

Alcohol drinking habit	Number of participants (*n* (%))	Hypertension			Alcohol-induced hypertension among total hypertensives (%)
		Cases	Prevalence (%)	Adjusted odds ratio* (95% confidence interval)	
Men					
Never drinkers	1,217 (35.2)	508	41.7	1.00	
1 *gou*/day	998 (28.9)	514	51.5	1.74 (1.45–2.10)	12.7
2 *gou*/day	694 (20.1)	371	53.5	2.06 (1.67–2.53)	11.1
3 *gou*/day or more	302 (8.7)	168	55.6	2.46 (1.86–3.25)	5.8
Ex-drinkers	243 (7.0)	160	65.8	2.05 (1.49–2.81)	4.8
Women					
Never drinkers	4,442 (92.4)	1,923	43.3	1.00	
1 *gou*/day	251 (5.2)	101	40.2	1.58 (1.17–2.14)	1.8
2 *gou*/day or more	63 (1.3)	30	47.6	2.09 (1.17–3.72)	0.7
Ex-drinkers	52 (1.1)	20	38.5	0.94 (0.49–1.79)	−0.1

One *gou* contains 23.0 g of alcohol. Hypertension was defined as a systolic blood pressure ≥140 mmHg, a diastolic blood pressure ≥90 mmHg, the use of antihypertensive agents, or any combination of these. *Odds ratios were calculated by a logistic regression model adjusted for age and body mass index.

hypertension among all hypertensives (*22*). Therefore, only data from a nationwide random sampling survey such as ours will generate a reliable estimate of the proportion of individuals with alcohol-induced hypertension among all hypertensives in the general Japanese population.

Previously, Ueshima *et al.* (*16*) reported that hypertension in 32% of Japanese hypertensive men (based on previous criteria of systolic blood pressure ≥160 mmHg, diastolic blood pressure ≥95 mmHg, the use of antihypertensive agents, or any combination of these) aged 30–69 could be attributed to alcohol drinking using data from the nationwide survey in 1980. In 1990, using more recent criteria for hypertension (*17*) (*i.e.*, different from the above criteria), we calculated the odds ratio for the prevalence of hypertension in drinkers, and estimated the percentage of Japanese hypertensives whose condition could be attributed to alcohol. It is difficult to compare our results directly with the corresponding proportion in other countries due to the lack of available data. However, Japanese men consume more alcoholic beverages than men in many other developed countries (*11–15*). Klag *et al.* (*12*) previously reported that, in the 1970s, the prevalences of daily drinkers in a male population aged 35–59 working for an office in Japan or the United States were 48% (heavy drinkers, 6%) and 40% (heavy drinkers, 0%), respectively, and then estimated that hypertension in 29% of Japanese and 21% of American hypertensives (based on the same previous criteria) could be attributed to daily alcohol consumption (*12*). The prevalence of daily drinkers in Japanese male office workers is almost the same as the results from the nationwide survey in 1980 (*16*), although we do not have any information on the prevalence of daily drinkers in the whole male population in the United States at that time. In addition, Zhou *et al.* (*13*) recently reported that in the 1990s, the mean alcohol intake per day in a male population aged 40–59 was 186.8 kcal for Japan, 70.4 kcal for the United States and 116.1 kcal for the United Kingdom (7 kcal = 1.0 g of alcohol). Judging from these observations, the proportion of individuals with alcohol-induced hypertension among all hypertensives might be much higher in the Japanese male population than in the male population in other developed countries such as the United States and the United Kingdom.

We demonstrated that even a low-to-moderate alcohol intake of 1 *gou*/day contributes to the high prevalence of hypertension in Japan. Approximately 37% of all men and 75% of all women with alcohol-induced hypertension had a low-to-moderate alcohol intake. This is because the number of low-to-moderate drinkers was much greater than the number of heavy drinkers of 2 *gou*/day or more; approximately 50% of male current drinkers and 80% of female current drinkers were in the category of low-to-moderate alcohol intake. These results suggest that moderation of alcohol intake is not enough to reduce the prevalence of hypertension in the Japanese population. From the viewpoint of preventing hypertension, quitting habitual alcohol intake or never drinking in the first place may be required rather than reducing alcohol intake. However, a J-shaped association between alcohol intake and arterial stiffness quantified by pulse wave velocity has been suggested (*26*), even among normotensive individuals (*27*). A J-shaped association between alcohol intake and coronary heart disease (*28, 29*) or ischemic stroke (*30*) has also been suggested. Therefore, the protective effect of light-to-moderate alcohol intake on atherosclerotic cardiovascular risk should also be included in the overall consideration of the influence of alcohol drinking on human health.

The present study has several limitations. First, in the interview used to assess alcohol intake habits, each participant chose the category most applicable to his or her habit among the five categories on the basis of his or her own judgement. It is possible that some participants who occasionally consume alcoholic beverages choose "never drinker," and this might have underestimated the true proportion of individuals with alcohol-induced hypertension among total hypertensives, because even such drinkers are likely to be at risk for hypertension (*10*). Second, we did not take the type of alcoholic beverages consumed into consideration in our analysis, because this information was not available. However, Okamura *et al.* (*31*) reported that the effect of alcohol consumption on blood pressure does not depend on the type of alcoholic beverages consumed. Thus, information on the type of alcoholic beverages consumed may have little effect on the results of the present study. Third, blood pressure–related social factors (*e.g.*, stress, irregular lifestyle) and dietary factors (*e.g.*, sodium intake, potassium intake) were not adjusted in the analysis, because these data were also not available. However, Choudhury *et al.* (*32*) reported that there was little difference in sodium and potassium intake between Japanese male drinkers and never drinkers. Finally, our results are based on data from the survey conducted in 1990. The latest nationwide survey (the Fifth National Survey on Circulatory Disorders, Japan in 2000) (*33*) shows that the prevalences of alcohol drinkers (including ex-drinkers) and hypertensives are 62.4% (daily drinkers, 53.6%; ex-drinkers, 8.8%) and 57.1% for men, and 10.7% (daily drinkers, 9.3%; ex-drinkers, 1.5%) and 45.3% for women, respectively. We still observed a high prevalence of alcohol drinkers and hypertensives in men in 2000. Therefore, we believe that the proportion of individuals with alcohol-induced hypertension among total hypertensives remains quite high in the general Japanese male population.

In conclusion, alcohol consumption plays an important role in the high prevalence of hypertension in the Japanese male population. Thus, in any public health approach to combating hypertension, attention should be paid to alcohol consumption. This is also applicable to other countries where the prevalence of alcohol consumption remains high or is increasing.

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Appendix

List of the NIPPON DATA90 Research Group

NIPPON DATA90: National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged.

Chairman: Hirotsugu Ueshima (Department of Health Science, Shiga University of Medical Science, Otsu, Shiga).

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日本人集団の肥満に起因すると考えられる高血圧の割合；NIPPON DATA80, 90 のベースライン調査による検討

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【 目的 】

わが国では肥満の頻度が増加傾向にある。肥満は高血圧の原因の一つであり、その日本人の高血圧有病率への影響は大きくなっていると予想される。1980 年と 1990 年に日本全国から無作為に選ばれた地域在住の高血圧者集団の中で肥満に起因した高血圧者の割合を男女別に推定することを試みた。

【 方法 】

1980 年のデータとして日本人男性 4,640 名、女性 5,906 名（ともに平均年齢は 50 歳）、1990 年のデータとして日本人男性 3,504 名、女性 4,880 名（ともに平均年齢は 53 歳）の Body Mass Index（以下、BMI）値、血圧値などの情報が解析に利用された。ロジスティック回帰分析を用いて、高血圧に対する BMI 高値のオッズ比が計算され、高血圧者集団の中で肥満に起因したと考えられる高血圧者の割合が推定された。

【 結果 】

1980 年の男性の全対象者の中で、肥満（25.0≦BMI）を有する者は 18.8%、高血圧（収縮期血圧 140mmHg 以上、拡張期血圧 90mmHg 以上、降圧剤服用中のいずれか）を有する者は 50.4%であった。女性の全対象者の中では、肥満を有する者は 22.6%、高血圧を有する者は 41.1%であった。高血圧に対する肥満のオッズ比（年齢、飲酒、喫煙を調整）は男性 2.03 (95%信頼区間, 1.73-2.39)、女性 2.57 (2.24-2.96)であった。そして、高血圧者集団の中で肥満に起因したと考えられる高血圧者の割合は男性では 11.4% (95%信頼区間, 4.7%-17.7%)、女性では 19.3% (12.1%-25.9%)であった。同様にして、肥満の程度（25.0≦BMI＜30.0、30.0≦BMI）毎に高血圧に対するオッズ比を計算したところ、表に示すとおり男女とも BMI 値が高いほどオッズ比が高くなる傾向を示した。男性の高血圧者集団の中で肥満に起因したと考えられる高血圧者の割合約 11.4%の内訳は 25.0≦BMI＜30.0 が 10.7%、30.0≦BMI が 0.7%であった。一方、女性の高血圧者集団の中で肥満に起因したと考えられる高血圧者の割合約 19.3%の内訳は 25.0≦BMI＜30.0 が 15.9%、30.0≦BMI が 3.8%であった。1990 年の男性の全対象者の中で、肥満を有する者は 23.7%、高血圧を有する者は 49.8%であり、女性ではそれぞれ 23.8%、43.1%であった。高血圧に対する肥満のオッズ比は男性 2.15 (1.81-2.56)、女性 2.77 (2.37-3.23)で、高血圧者集団の中で肥満に起因したと考えられる高血圧者の割合は男性では 15.3% (6.8%-23.1%)、女性では 22.3% (14.6%-29.3%)であった。同様にして計算した肥満の程度毎の高血圧に対するオッズ比は男女とも BMI 値が高いほどオッズ比が高くなる傾向を示した（表）。男性の高血

圧者集団の中で肥満に起因したと考えられる高血圧者の割合約 15.3%の内訳は 25.0≦BMI＜30.0 が 13.3%、30.0≦BMI が 2.0%であり、女性の肥満に起因したと考えられる高血圧者の割合約 22.3%の内訳は 25.0≦BMI＜30.0 が 18.4%、30.0≦BMI が 3.8%であった。

【 結論 】日本人の肥満に起因する高血圧の割合は大きくなっていたと考えられる。適正体重維持の啓発は日本人の高血圧予防のために重要な施策である。

表. BMIレベル毎の高血圧者の頻度、高血圧に対する肥満のオッズ比と全高血圧者の中で肥満が起因していると推測される高血圧者の割合 (NIPPON DATA90)

BMI	対象者数 (分布(%))	高血圧者数	高血圧頻度 (%)	オッズ比 * (95%信頼区間)	各BMIレベルに起因した高血圧者の割合(%)
1980年					
男性					
BMI＜25.0	3,752 (81.2)	1,806	48.1	1.00	
25.0≦BMI＜30.(	829 (17.9)	497	60.0	2.01 (1.70-2.37)	10.7
30.0≦BMI	42 (0.9)	27	64.3	2.63 (1.34-5.20)	0.7
女性					
BMI＜25.0	4,562 (77.4)	1,640	35.9	1.00	
25.0≦BMI＜30.(	1,155 (19.6)	660	57.1	2.40 (2.07-2.78)	15.9
30.0≦BMI	176 (3.0)	121	68.8	4.17 (2.92-5.95)	3.8
1990年					
男性					
BMI＜25.0	2,636 (76.3)	1,228	46.6	1.00	
25.0≦BMI＜30.(	758 (21.9)	450	59.4	2.04 (1.70-2.44)	13.3
30.0≦BMI	60 (1.7)	43	71.7	4.59 (2.50-8.42)	2.0
女性					
BMI＜25.0	3,666 (76.2)	1,351	36.9	1.00	
25.0≦BMI＜30.(	999 (20.8)	621	62.2	2.60 (2.20-3.05)	18.4
30.0≦BMI	143 (3.0)	102	71.3	4.50 (3.00-6.80)	3.8

* 年齢, 飲酒, 喫煙を調整

【 研究成果の公表 】

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CARDIOVASCULAR DISEASE

The proportion of individuals with obesity-induced hypertension among total hypertensives in a general Japanese population: NIPPON DATA80, 90

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Abstract The increased prevalence of obesity in Japan may contribute to the high prevalence of hypertension in Japan. In the present study, we calculated the odds ratio for hypertension in obesity (body mass index (BMI) $\geq$ 25.0 kg/m^2) using data from independent nationwide surveys conducted in 1980 and 1990. We estimated the percentage of hypertensives whose condition was due to obesity among total hypertensives in the general Japanese population. In the 1980 survey, 18.8% of 4,623 male participants were obese and 50.4% were hypertensive, whereas 22.6% of 5,893 female participants were obese and 41.1% were hypertensive. For both sexes, obese participants had a higher odds ratio for hypertension than non-obese participants (BMI < 25.0 kg/m^2), and there was a significant dose–response relationship between BMI and the odds ratio for hypertension. Among all hypertensives, the percentage whose hypertension was due to obesity in 1980 and 1990 was 11.4% (95% confidence interval (CI): 4.7–17.7%) and 15.3% (95% CI: 6.8–23.1%) for men and 19.3% (95% CI: 12.1–25.9%) and 22.3% (95% CI: 14.6–29.3%) for women, respectively. Approximately 80–90% of individuals with obesity-induced hypertension were in the 25.0 $\leq$ BMI < 30.0 kg/m^2 category for both sexes in each year. In conclusion, we found that obesity-induced hypertension as a proportion of total hypertension increased between 1980 and 1990 for both sexes. Obesity now is playing a more important role in the high prevalence of hypertension in Japan than it was before.

Keywords Obesity · Body mass index · Hypertension · Japan

NIPPON DATA80, 90 Research Group—Members of the Research Group are listed in the Appendix.

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Introduction

The high prevalence of hypertension in Japan has been mainly attributed to both high sodium [1–5] and high alcohol intake, at least among men [2, 4, 6–8]. The mean body mass index (BMI) in the Japanese population in 1960 was less than 22 kg/m^2 [2, 9], far lower than that in the Western population (approximately 25 kg/m^2) [10]. Thus, obesity was not a significant factor in hypertension for the Japanese population at that time. However, the mean BMI of the Japanese population increased significantly over subsequent decades [2, 9, 11]. As a result, obesity may now be playing a more important role in the high prevalence of hypertension in Japan than it was before [2, 4, 11–14]. Therefore, it is important to clarify how much obesity is contributing to the high prevalence of hypertension in Japan.

In the present study, we measured and compared the proportion of individuals with obesity-induced hypertension among total hypertensives in both 1980 and 1990 in populations selected randomly from the overall Japanese population.

Population and methods

Study design and participants

NIPPON DATA (National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged) is a series of cohort studies conducted by the National Survey on Circulatory Disorders, Japan. The details of these cohort studies have been previously reported [15–20]. In the present study, we analyzed baseline data from NIPPON DATA80 (data from the Third National Survey on Circulatory Disorders, Japan in 1980) and NIPPON DATA90 (data from the Fourth National Survey on Circulatory Disorders, Japan in 1990). The 1980 and 1990 surveys were conducted in independent populations, which comprise different participants.

In the 1980 survey, a total of 10,546 community residents (4,640 men and 5,906 women; ≥ 30 years old) participated from 300 randomly selected districts. The overall population aged 30 and over in all districts was 13,771, and the participation rate in this survey was 76.6%. Of the 10,546 participants, 30 were excluded due to missing information in the baseline survey. The remaining 10,516 participants (4,623 men and 5,893 women) were included in the analysis.

Similarly, in the 1990 survey, a total of 8,384 residents (3,504 men and 4,880 women; ≥ 30 years old) participated, comprising 76.5% of 10,956 residents aged 30 and over. Of the 8,384 participants, 122 were excluded due to missing information in the baseline survey. The remaining 8,262 participants (3,454 men and 4,808 women) were included in the analysis. Accordingly, the participants in these surveys were thought to be representative of the Japanese population.

The present study was approved by the Institutional Review Board of Shiga University of Medical Science for Ethical Issues (No.12–18, 2000).

Examination

In both surveys, body mass index (BMI) was calculated as weight (kg) divided by the square of height (m). Obesity was defined as a BMI $\geq$ 25.0 kg/m^2 [22]. In order to estimate the proportion of individuals with obesity-induced hypertension among total hypertensive participants in the study populations, the participants were classified into two categories: "BMI < 25.0 (kg/m^2)" and "BMI $\geq$ 25.0 (kg/m^2)". Additionally, in order to investigate the details of the corresponding proportion, obese participants were stratified into two further categories: "25.0 $\leq$ BMI < 30.0 (kg/m^2)" and "BMI $\geq$ 30.0 (kg/m^2)". These ranges were in accordance with the obesity classification system of the Japan Society for the Study of Obesity [21] and that of the World Health Organization [22].

Baseline blood pressures were measured by trained observers using a standard mercury sphygmomanometer on the right arm of seated participants after a sufficient period of rest. Information on use of anti-hypertensive agents was obtained by public health nurses. According to the Seventh Report of the Joint National Committee [23], hypertension was defined as a systolic blood pressure $\geq$ 140 mmHg, a diastolic blood pressure $\geq$ 90 mmHg, the use of anti-hypertensive agents, or any combination of these. Alcohol drinking and smoking habits were also assessed by interviews with public health nurses.

Statistical analysis

Initially, we analyzed data from the 1980 and 1990 surveys using one-way analysis of variance or a Chi-square test to compare baseline risk characteristics among the different BMI categories. Next, we calculated the prevalence of hypertension in each of two BMI categories ("BMI < 25.0 (kg/m^2)" and "BMI $\geq$ 25.0 (kg/m^2)") in 1980 and 1990. Using a logistic regression model, the significance of an interaction between hypertension, obesity and sex was tested using an interaction term for the categorical variables (2 categories for sex, and 3 categories for BMI). The odds ratio for hypertension in each BMI category was calculated with BMI < 25.0 serving as a reference. Age (continuous variable), alcohol drinking habit (never, ex- or current drinker, using two dummy variables with never serving as a reference) and smoking habit (never, ex- or current smoker, using two dummy variables with never serving as a reference) were included in the regression models as potential confounding variables. We calculated the percentage of individuals with obesity-induced hypertension among total hypertensives in 1980 and 1990 using the following equation: [prevalence of obesity among hypertensives $\times$ (odds ratio $-$ 1)]/odds ratio [24]. The 95% confidence interval (CI) for the corresponding proportion was calculated using the formula proposed by Greenland [25]. Finally, in order to investigate the details of the corresponding proportion, we analyzed the data using the above equation after classifying the participants into three BMI categories ("BMI < 25.0 (kg/m^2)", "25.0 $\leq$ BMI < 30.0 (kg/m^2)" and "BMI $\geq$ 30.0 (kg/m^2)").

The statistical analysis was performed using SPSS 14.0J for Windows (SPSS Japan Inc., Tokyo, Japan). *P* values were two-sided, and values of $p < 0.05$ were considered statistically significant.

Results

For the 1980 survey, the mean values or proportions of risk characteristics for male and female participants grouped

according to their BMI are summarized in Table 1. Of the 4,623 male participants (mean age, 49.9 years old; mean body height, 162.2 cm; mean body weight, 59.3 kg; mean BMI, 22.5 kg/m^2), 18.8% were obese and 50.4% were hypertensive, whereas 22.6% of the 5,893 female participants (mean age, 50.1 years old; mean body height, 150.1 cm; mean body weight, 51.5 kg; mean BMI, 22.8 kg/m^2) were obese and 41.1% were hypertensive. For both sexes, there were little differences in the mean values of body height among the three BMI categories, although there were large differences in the mean values of body weight. For men, the mean values of age in the two obese categories were lower than in the non-obese category, whereas for women, the mean values of age in the two obese categories were higher than in the non-obese category.

In the 1980 survey, there was no interaction of hypertension with obesity and sex ($p = 0.14$). For both sexes, an obese participant with a BMI $\geq$ 25.0 kg/m^2 had a higher prevalence of hypertension (60.2% vs. 48.1% for men, and 58.7% vs. 35.9% for women) and a significantly higher odds ratio for hypertension (2.03; 95% CI: 1.73–2.39 for men, and 2.57; 95% CI: 2.24–2.96 for women), as compared to a non-obese participant with a BMI < 25.0 kg/m^2. The proportion of individuals with obesity-induced hypertension among total hypertensives was estimated to be 11.4% (95% CI: 4.7–17.7%) for men and 19.3% (95% CI: 12.1–25.9%) for women (the results described above are not shown in the Table). There was a dose–response relationship between BMI and odds ratio for hypertension in both sexes (Table 2). Table 2 shows the percentage of individuals with obesity-induced hypertension among total hypertensives in each of the further stratified BMI categories. The proportion of individuals with obesity-induced hypertension was much higher in the 25.0 $\leq$ BMI < 30.0 (kg/m^2) category than in the BMI $\geq$ 30.0 (kg/m^2) category for both sexes.

For the 1990 survey, the mean values or proportions of risk characteristics for male and female participants grouped according to their BMI are summarized in Table 1. Of the 3,454 male participants (mean age, 53.3 years old; mean body height, 163.6 cm; mean body weight, 61.6 kg; mean BMI, 23.0 kg/m^2), 23.7% were obese and 49.8% were hypertensive, whereas 23.8% of the 4,808 female participants (mean age, 52.7 years old; mean body height, 151.2 cm; mean body weight, 52.2 kg; mean BMI, 22.8 kg/m^2) were obese and 43.1% were hypertensive. Similar to the 1980 survey, there was little difference in the mean values of body height among the three BMI categories for both sexes, although there were significant differences in the mean values of body weight. Furthermore, for men, the mean values of age in the two obese categories were lower than that in the non-obese category, whereas for women, the mean values of age in the two obese categories were higher than that in the non-obese category.

In the 1990 survey as well as the 1980 survey, there was no interaction of hypertension with obesity and sex ($p = 0.31$). For both sexes, an obese participant with a BMI $\geq$ 25.0 kg/m^2 had a higher prevalence of hypertension (60.3% vs. 46.6% for men, and 63.3% vs. 36.9% for women) and a significantly higher odds ratio for hypertension (2.15; 95% CI: 1.81–2.56 for men, and 2.77; 95% CI: 2.37–3.23 for women), as compared to a non-obese participant with a BMI < 25.0 kg/m^2. The proportion of individuals with obesity-induced hypertension among total hypertensives was estimated to be 15.3% (95% CI: 6.8–23.1%) for men and 22.3% (95% CI: 14.6–29.3%) for women (the results described above are not shown in the Table). There was a dose–response relationship between BMI and odds ratio for hypertension in both sexes (Table 2). Table 2 shows the percentage of individuals with obesity-induced hypertension among total hypertensives stratified further into a number of BMI categories. The proportion of individuals with obesity-induced hypertension was much higher in the 25.0 $\leq$ BMI < 30.0 (kg/m^2) category than in the BMI $\geq$ 30.0 (kg/m^2) category for both sexes.

Discussion

In the present study, we demonstrated the increased proportion of individuals with obesity-induced hypertension (BMI $\geq$ 25.0 kg/m^2) among total hypertensives over a decade between 1980 and 1990 for both sexes. Only data from a nationwide random sampling survey such as ours is able to generate a reliable estimate of the prevalence of obesity and hypertension in the whole Japanese population and the proportion of individuals with obesity-induced hypertension among total hypertensives in Japan, which is a major strength of the present study.

Obesity is associated with the development of hypertension [26–32]. Mechanisms of the development of hypertension among obese individuals include hyperinsulinemia, insulin-induced sodium retention and increased sympathetic tone [32]. Previously, Takashima [33] reported that 9.4% of middle-aged male hypertensives in a corporation in Japan had obesity-induced hypertension (BMI $\geq$ 25.0 kg/m^2) in a cross-sectional study in 1980. Our result is fairly consistent with this finding. For Western populations, with a higher mean BMI compared to Japanese and other Asian populations [34], obesity is generally defined as a BMI $\geq$ 30.0 kg/m^2, and a condition of 25.0 $\leq$ BMI < 30.0 kg/m^2 is regarded as overweight [22]. However, here, we compared our results with results from

Table 1 Baseline risk characteristics in 1980 and 1990 of Japanese participants based on sex and body mass index: NIPPON DATA80, 90

	Men				Women			
	Body mass index (BMI) (kg/m^2)				Body mass index (BMI) (kg/m^2)			
	BMI < 25.0	25.0 ≤ BMI < 30.0	30.0 ≤ BMI		BMI < 25.0	25.0 ≤ BMI < 30.0	30.0 ≤ BMI	
In 1980								
Number of participants (percentage)	3,758	830	42		4,565	1,155	176	
	(81.2)	(17.9)	(0.9)		(77.4)	(19.6)	(3.0)	
Age (years)	50.4 ± 13.7	47.9 ± 11.6	48.0 ± 12.5	*	49.5 ± 13.7	51.9 ± 12.3	52.6 ± 12.3	*
Body height (cm)	162.1 ± 6.8	162.8 ± 6.2	161.6 ± 9.1	*	150.4 ± 6.2	149.3 ± 5.7	148.7 ± 6.0	*
Body weight (kg)	56.6 ± 7.3	70.6 ± 6.2	81.7 ± 7.7	*	48.6 ± 6.1	60.0 ± 5.2	71.6 ± 8.3	*
Body mass index (kg/m^2)	21.5 ± 2.0	26.6 ± 1.2	31.3 ± 1.7	*	21.4 ± 2.1	26.9 ± 1.3	32.3 ± 2.2	*
Alcohol drinking habit								*
Ex-drinker (%)	5.9	5.4	4.8		1.6	2.0	2.3	
Current daily drinker (%)	74.1	75.3	66.7		21.3	17.0	17.0	
Smoking habit				*				
Ex-smoker (%)	18.4	20.0	31.0		2.3	2.7	3.4	
Current smoker (%)	64.7	56.2	50.0		10.0	10.0	5.1	
Systolic blood pressure (mmHg)	137.6 ± 21.2	141.6 ± 19.7	143.0 ± 22.5	*	131.4 ± 20.9	141.5 ± 22.2	146.9 ± 22. 3	*
Diastolic blood pressure (mmHg)	82.6 ± 12.1	87.6 ± 12.5	90.9 ± 13.5	*	78.1 ± 11.7	83.8 ± 11.5	88.9 ± 13.5	*
Use of anti-hypertensive agents (%)	9.8	13.5	14.3	*	9.2	19.3	31.8	*
In1990								
Number of participants (percentage)	2,636	758	60		3,666	999	143	
	(76.3)	(21.9)	(1.7)		(76.2%)	(20.8)	(3.0)	
Age (years)	53.8 ± 14.0	51.8 ± 12.6	49.5 ± 12.4	*	51.8 ± 14.3	55.9 ± 12.8	55.3 ± 12.7	*
Body height (cm)	163.5 ± 6.9	164.1 ± 6.6	164.8 ± 6.6	*	151.6 ± 6.6	150.0 ± 6.4	150.0 ± 6.0	*
Body weight (kg)	58.2 ± 7.5	71.7 ± 6.5	86.5 ± 9.6	*	49.3 ± 6.2	60.3 ± 5.8	72.0 ± 7.3	*
Body mass index (kg/m^2)	21.7 ± 2.1	26.6 ± 1.2	31.8 ± 2.3	*	21.4 ± 2.1	26.8 ± 1.3	31.9 ± 1.9	*
Alcohol drinking habit								
Ex-drinker (%)	7.2	6.7	5.0		1.1	1.0	0.7	
Current daily drinker (%)	56.9	60.7	58.3		6.9	5.1	6.3	
Smoking habit								
Ex-smoker (%)	23.1	25.7	30.0		2.7	2.7	2.8	
Current smoker (%)	55.6	54.1	45.0		9.4	9.2	13.3	
Systolic blood pressure (mmHg)	136.6 ± 20.3	140.6 ± 18.2	148.9 ± 19.2	*	131.0 ± 20.2	141.3 ± 20.0	148.7 ± 22. 9	*
Diastolic blood pressure (mmHg)	82.4 ± 11.4	86.9 ± 11.4	91.9 ± 10.2	*	77.8 ± 11.2	84.6 ± 11.6	87.5 ± 13.8	*
Use of anti-hypertensive agents (%)	11.7	16.0	25.0	*	12.5	25.2	32.2	*

Values indicate the mean ± SD or the % of participants in that category

Mean values or proportions were compared among the three BMI categories by one way analysis of variance or a Chi square test;* statistical significance ($p < 0.05$)

Table 2 Prevalence of hypertension, odds ratio for hypertension in obesity, and proportion of individuals with obesity-induced hypertension among total hypertensives in 1980 and 1990 grouped by sex and body mass index: NIPPON DATA80, 90

Body mass index (BMI) (kg/m^2)	Number of participants (percentage)	Hypertension			Obesity-induced hypertension among total hypertensives (%)
		Cases	Prevalence (%)	Adjusted odds ratio (95% confidence interval)	
In 1980					
Men					
BMI < 25.0	3,752 (81.2)	1,806	48.1	1.00	
25.0 ≤ BMI < 30.0	829 (17.9)	497	60.0	2.01 (1.70–2.37)*	10.7
30.0 ≤ BMI	42 (0.9)	27	64.3	2.63 (1.34–5.20)*	0.7
Women					
BMI < 25.0	4,562 (77.4)	1,640	35.9	1.00	
25.0 ≤ BMI < 30.0	1,155 (19.6)	660	57.1	2.40 (2.07–2.78)*	15.9
30.0 ≤ BMI	176 (3.0)	121	68.8	4.17 (2.92–5.95)*	3.8
In 1990					
Men					
BMI < 25.0	2,636 (76.3)	1,228	46.6	1.00	
25.0 ≤ BMI < 30.0	758 (21.9)	450	59.4	2.04 (1.70–2.44)*	13.3
30.0 ≤ BMI	60 (1.7)	43	71.7	4.59 (2.50–8.42)*	2.0
Women					
BMI < 25.0	3,666 (76.2)	1,351	36.9	1.00	
25.0 ≤ BMI < 30.0	999 (20.8)	621	62.2	2.6 (2.20–3.05)*	18.4
30.0 ≤ BMI	143 (3.0)	102	71.3	4.5 (3.00–6.80)*	3.8

Obesity was defined as a body mass index ≥ 25.0 kg/m^2, and hypertension was defined as a systolic blood pressure ≥ 140 mmHg, a diastolic blood pressure ≥ 90 mmHg, the use of antihypertensive agents, or any combination of these

Odds ratios were calculated by a logistic regression model adjusted for age, alcohol drinking habit and smoking habit; * statistical significance ($p < 0.05$), vs. BMI < 25.0