3．受診者の満足と安心

3.1 受診者のプライバシーへの配慮がなされている

3.1.1 検査や診察、指導等を受ける際のプライバシーが確保されている (5･4･3･2･1･NA)

(ｺﾒﾝﾄ)

注)個人名で放送による呼び出しを行うなどの場合は適切さに欠けるとする。ポケベル、番号、番号テロップ等プライバシーを守る具体的な方策があればよい。
▽病院併設等の場合、一般受診者と区別し、健診受診者への何らかの配慮があることが望ましい。 ◇施設見取り図（平面図）

3.1.1.1 検査室は個別に仕切られ、外から見えない構造になっている (a･b･c･NA)

注）検査室には、身体測定、血圧、採血、眼底等も含まれる。 ◆5.2.4.3

3.1.1.2 診察室・問診室・指導室は個別に仕切られ、外部に声が聞こえない構造になっている (a･b･c･NA)

3.1.1.3 検体が人目に触れないように配慮されている (a･b･c･NA)

注）検体とは、採血管や検尿コップなどをさす。 ◆5.2.4.3

注)検体は、他人から個人が特定できるようなものでない配慮が必要。

3.2 受診者の受付、検査予定・内容の説明が適切になされている

3.2.2 開始時に検査予定および内容が説明され、受診者の質問に答える姿勢がある (5･4･3･2･1･NA)

(ｺﾒﾝﾄ)

3.2.2.1 開始時に検査の予定および内容や注意点の説明がなされている (a･b･c･NA)

注)専任のコーディネーターを配置し対応規定を定めている。

注)業務指針、マニュアル化された文章、例示等があればよい。

3.2.3.1 健診中の質問に対しての対応のしかたが定められている (a･b･c･NA)

注)業務指針、マニュアル化された文章、例示等があればよい。◇対応マニュアルなど

3.3 受診後のフォローアップが適切になされている

3.3.1 受診後に連絡をするしくみがあり、精密検査や医療機関への受診が必要と判定された受診者については、受診経過のフォローがなされている (5･4･3･2･1･NA)

(ｺﾒﾝﾄ)

3.3.1.1 受診後にフォローアップの連絡をするしくみがある (a･b･c･NA)

注)業務指針、マニュアル化された文章、例示等があればよい。◇フォロー実績書類

3.3.2.1 必要な受診者については受診経過のフォローがなされ記録が残されている (a･b･c･NA)

注)所定用紙等があればなおよい。受診者ごとの個別のフォローが必要。
●平成20年4月以降、保健指導対象者のうち保健指導を受けなかった者又は保健指導を中断した者への対応として、対象者本人の意思に基づいた適切かつ積極的な対応を図ることが必要。

3.4 受診者の意見を反映する体制が確立している

3.4.1 受診者からの問い合わせに対応するしくみが確立している (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

注)ここでの「問い合わせ」とは、受診者或いは受診予定者からの健診に対する疑問や質問、時間、料金等の問い合わせ等をさす。 ◇対応記録など

3.4.1.2 受診者からの問い合わせの対応手順が定められている (a・b・c・NA)

注)マニュアル化され文章として残してあること。

3.4.1.3 受診者からの問い合わせの内容等が分析され、改善に役立てられている (a・b・c・NA)

注)何月何日誰が、どの部署が、委員会が内容をどのように処理しているのか、人権を重んじた対応をしてるかが重要。
●平成20年4月以降、受診者要望への積極的対応が図られているか、また苦情対応窓口などの設置を確認。また当該苦情の内容等を記録することが必要。

3.5 受診者の利便性に配慮がなされている

3.5.1 *受診者が受診しやすいような運営と*検査の流れが効率的であるように配慮されている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

●平成20年4月以降、総合的には、受診率・実施率向上のために受診者が受診しやすい運営体制かどうかも確認したうえで判断する。 ◇検査の流れに関する書類

3.5.1.1 *受診しやすい運営に配慮し*、検査の流れが効率的になるような配置になっている (a・b・c・NA)

注)施設内調査で確認し、何らかの方策がとられていればよい。
▽病院内併設型であっても、健診フロアはある程度まとまって存在するほうが望ましい。また一般の患者も同じ検査室を要する場合、利用状況を確認し、健診の流れに影響

3.5.1.3 施設内の案内表示が適切である (a・b・c・NA)

3.6 快適に受診できる環境が整備されている

3.6.1 施設内の清潔や禁煙に配慮されている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

3.6.2.1 施設内清掃が行き届いている (a・b・c・NA)

注)実際に施設内調査で各部署を確認すること。清潔さには臭気も含む。 ◆3.7.1.2

3.6.3.1 禁煙が徹底している (a・b・c・NA)

注)施設敷地内が完全禁煙であることを適切と評価する。

▽施設敷地内とは、健診施設（部門）としての管理が及ぶ範囲を指す。

注）職員においても禁煙が実施されている、受診者への周知協力に工夫があるなどの場合は、別途評価する。
●健康増進法第25条に定める受動喫煙の防止措置が講じられていれば不適切とは判断しない。

4．事業の質の確保

4.1 責任体制が明確にされている

4.1.1 検査ごとの担当者が明確にされ、医師による診察と検査結果の判定がなされている (5･4･3･2･1･NA)

(ｺﾒﾝﾄ)

4.1.1.1 担当医および検査担当者が定められ、受診者にわかるようになっている (a・b・c・NA)

注)担当医師・検査技師の名札が診察室・検査室ごとにわかりやすく明示されていること、明示していなければ適切さに欠けるとする。
注)検査結果表にも明示されていることが望ましい。
●平成20年4月以降、健康診断実施者は職員証など身分を証する書類を携行していること。

4.1.1.3 検査の種類に応じて担当者の配慮がなされている (a・b・c・NA)

注)女性専用検査への配慮がされていることが望ましい。

4.1.2.1 医師による診察と結果報告が行われている (a・b・c・NA)

注)全受診者に対し行われていることが望ましい。

4.2 適切な健康評価・健康指導がなされている

4.2.1 健診項目は適切で、成績の標準化がなされている (5･4･3･2･1･NA)

(ｺﾒﾝﾄ)

4.2.1.1 健診項目は基準検査項目がすべて含まれている (a・b・c・NA)

●平成20年4月以降、特定健診の指定検査項目が全て含まれていることの確認。
◇検査項目一覧◇オプション検査項目一覧

4.2.3.1 健診結果の判断基準が明確である (a・b・c・NA)

4.2.3.2 健診結果を提示するためのフォーマットが整備されている (a・b・c・NA)

●国が示す一定の様式であることの確認。

◇健診結果提示書式（フォーマット）

4.2.2 検査結果に基づいた健康や生活上の指導がなされている (5･4･3･2･1･NA)

(ｺﾒﾝﾄ)

注)実際に回って健康指導室、面談室等の確認をすること。人間ドックアドバイザーの配置が望ましい。
●特定保健指導のプログラムに応じて、再委託先や他の健康増進施設等と必要な連携を図ることが必要。また保健指導実施者は一定の研修を修了していることが望ましい。
●保健指導実施者は職員証など身分を証する書類を携行していること。

4.2.2.1 受診の必要性、生活習慣に関する指導、食事に関する指導などの保健指導が医師・保健師（看護師）・管理栄養士から行われている (a・b・c・NA)

4.2.2.4 必要があれば運動に関する指導が健康運動指導士またはトレーナーよりなされている (a・b・c・NA)

●平成20年4月以降、特定保健指導内容は「標準的な健診・保健指導プログラム」に準拠していることを確認。
●保健指導業務を統括するものは常勤の医師、保健師、管理栄養士であること。また初回面接、対象者の行動目標・支援計画の作成、保健指導の評価に関する業務を行う者は、医師、保健師、管理栄養士であること。ただし法施行後5年間に限り、一定の保健指導の実務経験のある看護師は行うことができる。
●食生活に関する指導人員については、THP養成の産業栄養指導担当者、産業保健指導担当者等。
●ここでいうトレーナーとは「運動に関する専門的知識及び技術を有する者」をさす。運動に関する指導人員については、健康スポーツ医やTHP養成の運動指導担当者、産業保健指導担当者等。

4.2.4 健診結果が経時的に管理され有効利用されている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

4.2.4.1 過去の健診結果が適切に保管されている (a・b・c・NA)

注)医療法に基づく保存が適切に行われていること（電子媒体も含め５年保存など）、セキュリティへの配慮が必要。医療情報システムの安全管理に関するガイドラインを遵守すること。 ◇検査判定書類など

4.2.4.2 健診時に過去の健診結果がすぐに参照できるようになっている (a・b・c・NA)

注)健診システムで画像・データがすぐに参照できるようなしくみが望ましい。

4.3 検査精度の管理がなされている

4.3.2 内部精度管理を行っている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

▽病院併設型等の場合、病院と一体で体制が整備されていればよい。

4.3.2.1 精度管理に関する規定が設けられている (a・b・c・NA)

注)書類で確認。

4.3.2.2 内部精度管理が定期的に行われている (a・b・c・NA)

注)どのような方法で行っているかを確認する。
●平成20年4月以降、特定健診において定める検査項目は、標準物質を使用していることの確認。外注にて実施する場合も同様の措置が必要。 ◇内部精度管理記録

4.3.3 外部の精度管理サーベイに参加している (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

4.3.3.1 外部の精度管理サーベイに参加している (a・b・c・NA)

●平成20年4月以降、日本医師会、日本臨床衛生検査技師会、全国労働衛生団体連合会および同等のレベルによるサーベイかを確認。 ◇外部精度管理サーベイ記録

4.3.3.2 外部の精度管理サーベイの結果を活用するしくみがある (a・b・c・NA)

注)結果を確認したり、検討したりしていればよい。

注) 検査を委託していればNAとする。

4.4 検査機器の管理が適切になされている

4.4.1 検査機器の点検が行われ、トラブルが発生した際の対応方法が確立している (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

▽病院併設型等の場合、病院と一体で整備されていてもよい。

4.4.1.2 検査機器の日常的な点検がおこなわれている (a・b・c・NA)

注) 始業点検マニュアル・点検記録を確認。（Ｘ線装置、生化学装置、心電計、眼底装置ほか）◇保守点検計画◇機器取扱マニュアル◇日常点検マニュアルなど

4.4.2.1 トラブル発生時の対処方法が明確になっている (a・b・c・NA)

▽病院で対応している場合は病院の対応マニュアルでもよい。◇トラブル発生対応マニュアルなど

4.5 感染管理の体制が整備されている

4.5.2 感染防止対策に取り組み、医療廃棄物の処理が適切になされている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

▽病院併設型等の場合、病院と一体で整備されていてもよい。

4.5.2.1 職員の感染防止マニュアルが整備されている (a・b・c・NA)

注) リキャップの禁止や予防接種の扱い等についての記載をチェックする。◇感染防止マニュアル

注) マニュアルに沿って実施していることを確認。

4.5.3.1 廃棄物処理マニュアルが整備されている (a・b・c・NA)

◇廃棄物処理マニュアル

4.5.3.2 廃棄物の分別・保管が適切である (a・b・c・NA)

注)針などの鋭利な感染性廃棄物などの分別・保管を確認する。

注)バイオハザードマークの適切な表示をチェックする。

4.6 リスクマネジメントの体制が整備されている

4.6.1 リスクマネジメントの体制が整えられている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

4.6.1.1 リスクマネジメントの担当者が定められている (a・b・c・NA)

注)担当者の役割分担を確認する。

▽病院に安全管理マニュアルの委員会があれば、そこに委員を派遣していればよい。◇委員会名簿など

4.6.1.2 リスクマネジメントのマニュアルが整備されている (a・b・c・NA)

▽病院で対応している場合は、病院での安全管理マニュアルでも可。◇リスクマネジメントマニュアル（事故発生防止マニュアル）

4.6.2.1 事故やインシデントを報告するしくみがある (a・b・c・NA)

注)インシデントレポートが綴られるなどファイリングされていることが必要。医師を含む専門職からの報告を確認。◇インシデントレポートなど

4.6.2.3 受診者の状態が急変した場合に対応するしくみがある (a・b・c・NA)

注) 救急カートなど対応できる体制を確認。

5．運営の合理性

5.2 情報管理が適切に行われている

5.2.2 情報機器が整備され、トラブル発生時の対応体制が確立している (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

5.2.1.1 情報管理を行う担当者が定められている (a・b・c・NA)

▽病院併設型等の場合、病院と一体で管理されていてもよい。

5.2.2.2 情報機器のトラブル発生時に対応する手順が定められている (a・b・c・NA)

▽病院内併設型の場合、病院で対応しているマニュアルでも可。
◇情報管理に関する規程など

5.2.3 データを保管する場所が定められ安全が確保されている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

5.2.3.1 データを保管する場所および利用できる人が定められている (a・b・c・NA)

注)場所の確認、安全確保の方策が必要。

5.2.3.2 情報機器のデータへのアクセス制限が考慮されている (a・b・c・NA)

5.2.4 個人情報保護に配慮した管理体制が整備されている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

注）取り扱いについては、個人情報の保護に関する法律およびこれに基づくガイドライン等を遵守していること。

5.2.4.1 個人情報の取り扱いに関する規約が定められている (a・b・c・NA)

注）受診者データのプライバシーの保護がどのようになされているのか確認。分析等を行うため、健診および保健指導結果を外部提供する際は、本来必要とされる範囲に限って提供し、当該個人情報を匿名化すること。◇個人情報保護に関する規程など

▽病院で専門の部署がある場合は組織図より確認。◇組織図・委員会名簿など

5.3 安全管理体制が確立している

5.3.1 施設の安全管理体制が確立している (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

5.3.1.1 安全衛生委員会等が組織されている (a・b・c・NA)

注）労働安全衛生法に基づいた体制が必要。
▽病院併設等の場合、健診部門の代表者が委員会に参画していることが必要。◇委員会名簿など

5.3.1.2 防火管理が行われている (a・b・c・NA)

注）消防法に基づいた体制、取り組みが必要。
▽病院併設の場合には病院と一体化した取り組みでも良い。◇防火管理者届出書類など

5.3.1.3 職員の健康管理が行われている (a・b・c・NA)

注）特に医師、非常勤職員の場合の受診確認が必要。

5.4 受診者に関する統計資料が作成されている

5.4.1 受診者に関する統計資料が作成され、運営に活用されている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

5.4.1.1 受診者に関する統計資料を作成する担当者がいる (a・b・c・NA)

注)誰が行なっているのか確認。
▽病院併設型等の場合、担当者が健診部門の者でなく病院（本部）等の部署の者でも明確であればよい。◇受診者統計資料など ◆2.1.2.2◆4.2.2.5

5.4.1.2 統計資料が運営に活用されている (a・b・c・NA)

注）統計資料を活用して次年度計画を作成していることが望ましい。

5.5 委託による業務の管理が適切になされている

5.5.1 委託業者の選定・管理が適切に行われている (5・4・3・2・1・NA)

(ｺﾒﾝﾄ)

●平成20年4月以降、特定健診・特定保健指導範囲の委託は国の基準を遵守していることが必要。
▽病院併設型等の場合、病院と一体で管理されていてもよい。

5.5.1.1 委託業者の選定が公正に行われている (a・b・c・NA)

注）選定ルールが明文化され、公正に選定されていることが必要。◇委託業者選定の規程など

5.5.1.2 委託業者との契約が定期的に見直されている (a・b・c・NA)

注)内容、期間、費用等を定めた契約書が必要。また更新時の見直しを確認。◇契約書

5.5.3.1 施設内に委託業務の管理担当者が定められている (a・b・c・NA)

注)委託業者の種類の確認、給食、医療廃棄物、一般廃棄物、清掃、医療機器、ビルメンテナンス等その契約書類があること、誰が、どの部署が行なっているのか確認。
▽病院の別の部署で行なわれている場合は組織図で確認し、健診関連部分のコピーでも可、契約更改等日付の確認。

注)医療廃棄物の廃棄、管理方法、管理責任者の確認。

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Impact of body mass index on cholesterol levels of Japanese adults

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SUMMARY

There have been few studies that examine the relation between body mass index (BMI) and cholesterol in consideration of potential interactions between age, sex, BMI and cholesterol. We determined age-, sex- and BMI-specific cholesterol levels of Japanese adults using the 2001 health examination data (337,690 men and 293,918 women). Both total cholesterol (T-C) and low-density lipoprotein cholesterol (LDL-C) levels increased with age until 50 years of age in men and until 60 years of age in women. Linear regression analysis showed significant BMI-dependent increases of T-C and LDL-C in all age groups, but the regression coefficients of BMI in relation to T-C and LDL-C became lower in older age groups until 60 years of age, with the highest value at ages 20–29 years in men and at ages 30–39 years in women. This result was consistent with the result of multiple logistic regression analysis regarding the risk of having hypercholesterolaemia. Weight reduction should be more strongly recommended to younger people, especially men aged under 40 years and women aged under 50 years, to prevent developing hypercholesterolaemia.

Keywords: Cholesterol; body mass index; age distribution; sex distribution

INTRODUCTION

Hypercholesterolaemia is a main contributor of atherogenesis. In order to reduce morbidity and mortality from cardiovascular disease, it is important to maintain a desirable cholesterol level (1).

Sex hormones play a role in cholesterol metabolism (2,3), which results in significant differences in cholesterol levels between men and women (4–8). Population-based cross-sectional studies have shown a significant impact of age on cholesterol levels in both sexes, but more markedly in women (4–8).

Overweight and obesity are associated with increased risk of cardiovascular disease (9). It is thought that at least part of the increased risk of cardiovascular disease is explained by the effect of overweight and obesity on cholesterol metabolism (1,9). Many investigators have reported that cholesterol levels increase with body mass index (BMI), which has been used as a measure of overweight and obesity (5,10–14). The distribution of BMI, as well as cholesterol, may depend on age and sex (10,14–16). However, there have been few studies that examine the relation between BMI and cholesterol in consideration of potential interactions between age, sex, BMI and cholesterol. The impact of BMI on cholesterol levels may probably be under- or overestimated, when the effects of age and sex on the relation between BMI and cholesterol are not included in the analysis. Overweight and obesity can be modified through lifestyle therapy (9). A proper understanding of the relation between BMI and cholesterol may contribute to improving hypercholesterolaemia and consequently promote the prevention of cardiovascular disease. In this study, we determined age-, sex- and BMI-specific cholesterol levels of Japanese adults using the 2001 health examination data. The impact of BMI on cholesterol levels was evaluated separately for age and sex groups to examine the effects of age and sex on the relation between BMI and cholesterol.

METHODS

Multiphasic health examinations are annually performed according to the law in community and worksite in Japan. Electronic data of the health examinations in the year 2001 were accumulated from 24 different prefectural health service facilities affiliated with the Japan Association of Health Service (http://www.yobouigaku-chuo.or.jp). Database included age, sex and the following laboratory data: height, weight, blood pressure, total cholesterol (T-C), high-density lipoprotein cholesterol (HDL-C), triglyceride, blood glucose, uric acid, haemoglobin and liver function tests (17). This study was approved by the ethics committee of St Marianna

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University School of Medicine in March 2003 and has been conduced in accordance with the guidelines for epidemiological studies by the Japanese Ministry of Health, Labour and Welfare and the Japanese Ministry of Education, Culture, Sports, Science and Technology.

Eligible 631,608 adults (337,690 men and 293,918 women) aged 20 years or older, whose blood sample had been taken in the fasting state, were included in this study. Height and weight were measured according to a standard protocol with participants standing without shoes and heavy garments. Cholesterol concentrations (T-C and HDL-C) were determined by the enzymatic method on the day of blood collection in each health service facility of the Japan Association of Health Service, but internal and external quality control of laboratory data has regularly been performed in the health service facilities as instructed by the expert committee for data standardisation (17). In the recent quality control survey, the coefficients of variation for T-C and HDL-C are around 1 and 1–3%, respectively (18). Low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula for samples with triglyceride $\leq$400 mg/dl (4.52 mmol/l): LDL-C = T-C–HDL-C–triglyceride/5 (19). Hypercholesterolaemia was defined as T-C $\geq$ 240 mg/dl (6.20 mmol/l) or as LDL-C $\geq$ 160 mg/dl (4.13 mmol/l) (1). BMI, which was calculated as weight (kg) divided by square of height (m^2), was classified as underweight (−18.5), normal (18.6–24.9), overweight (25.0–29.9) and obesity (30.0+) (9).

The *t*-tests and the analysis of variance (ANOVA) were used to assess statistical differences between the mean values. The χ^2-test was used to assess statistical significance in the prevalence values. The relation between BMI and T-C as well as BMI and LDL-C was evaluated using linear regression models separately for age and sex groups. Moreover, odds ratios for having hypercholesterolaemia were calculated using multiple logistic regression model with age and BMI groups as the independent variables separately for men and women; in the first stage, 28 age and BMI groups were the independent variables with normal weight subjects aged 20–29 years as the reference; in the second stage, the analyses were repeated separately for age groups, and 4 BMI groups were the independent variables with normal weight subjects of the same ages as the reference. Probability values were two-tailed and a value of $p < 0.05$ was considered significant. Confidence intervals were estimated at the 95% level. All statistical analyses were performed using the Statistical Analysis Systems (SAS, version 8.2).

RESULTS

Figure 1 shows the distribution of BMI. The distribution of BMI was significantly associated with age in both men and women, but the age-dependent pattern differed between sexes. In men, the prevalence of overweight plus obesity was over 30% for ages 30–69 years and decreased with age after 70 years of age. The prevalence of underweight was in the 3% level for ages 30–69 years and increased with age after 70 years of age. In women, the prevalence of overweight plus obesity was 7.4% in the group of 20–29 years and increased with age up to 30.6% in the group of 70–79 years. The prevalence of underweight was 25.7% in the group of 20–29 years, decreased with age up to 4.8% in the group of 60–69 years and gradually increased after 70 years of age.

Table 1 presents the means and prevalence of hypercholesterolaemia for T-C. The mean T-C levels significantly varied according to age in both men and women. In men, the mean T-C levels increased with age up to 207 mg/dl (5.35 mmol/l) in the groups of 40–49 and 50–59 years and gradually decreased after 60 years of age. In women, the mean T-C levels increased with age up to 222 mg/dl (5.75 mmol/l) in the groups of 50–59 and 60–69 years and gradually decreased after 70 years of age. The prevalence of hypercholesterolaemia (T-C $\geq$ 240 mg/dl, 6.20 mmol/l) showed the corresponding age-dependent pattern, reaching the peak at ages 40–49 years in men (16.3%) and at ages 50–59 years in women (29.2%). The age-dependent increase of T-C was more pronounced in women than in men. Consequently, men had significantly higher T-C levels than women for ages 20–49 years but significantly lower T-C levels after 50 years of age. As shown in Figure 2, the distribution of T-C was shifted towards higher values in higher BMI groups in both men and women. The mean T-C levels and the prevalence of hypercholesterolaemia significantly increased with BMI in all age groups, but the BMI-dependent increase of T-C became smaller in older age groups in both men and women.

Table 2 presents the means and prevalence of hypercholesterolaemia for LDL-C. Similar to T-C, LDL-C showed significant relations with age and BMI in both men and women. In men, the mean LDL-C levels increased with age up to 125 mg/dl (3.23 mmol/l) in the group of 50–59 years and gradually decreased after 60 years of age. In women, the mean LDL-C levels increased with age up to 139 mg/dl (3.59 mmol/l) in the group of 60–69 years and gradually decreased after 70 years of age. The prevalence of hypercholesterolaemia (LDL-C $\geq$ 160 mg/dl, 4.13 mmol/l) reached the peak at ages 50–59 years in men (13.4%) and at ages 60–69 years in women (23.1%). Men had significantly higher LDL-C levels than women for ages 20–49 years but significantly lower LDL-C levels after 50 years of age. As shown in Figure 3, the distributison of LDL-C was shifted towards higher values in higher BMI groups. The mean LDL-C levels and the prevalence of hypercholesterolaemia significantly increased with BMI in all age groups, but the BMI-dependent increase of LDL-C became smaller in older age groups in both men and women.

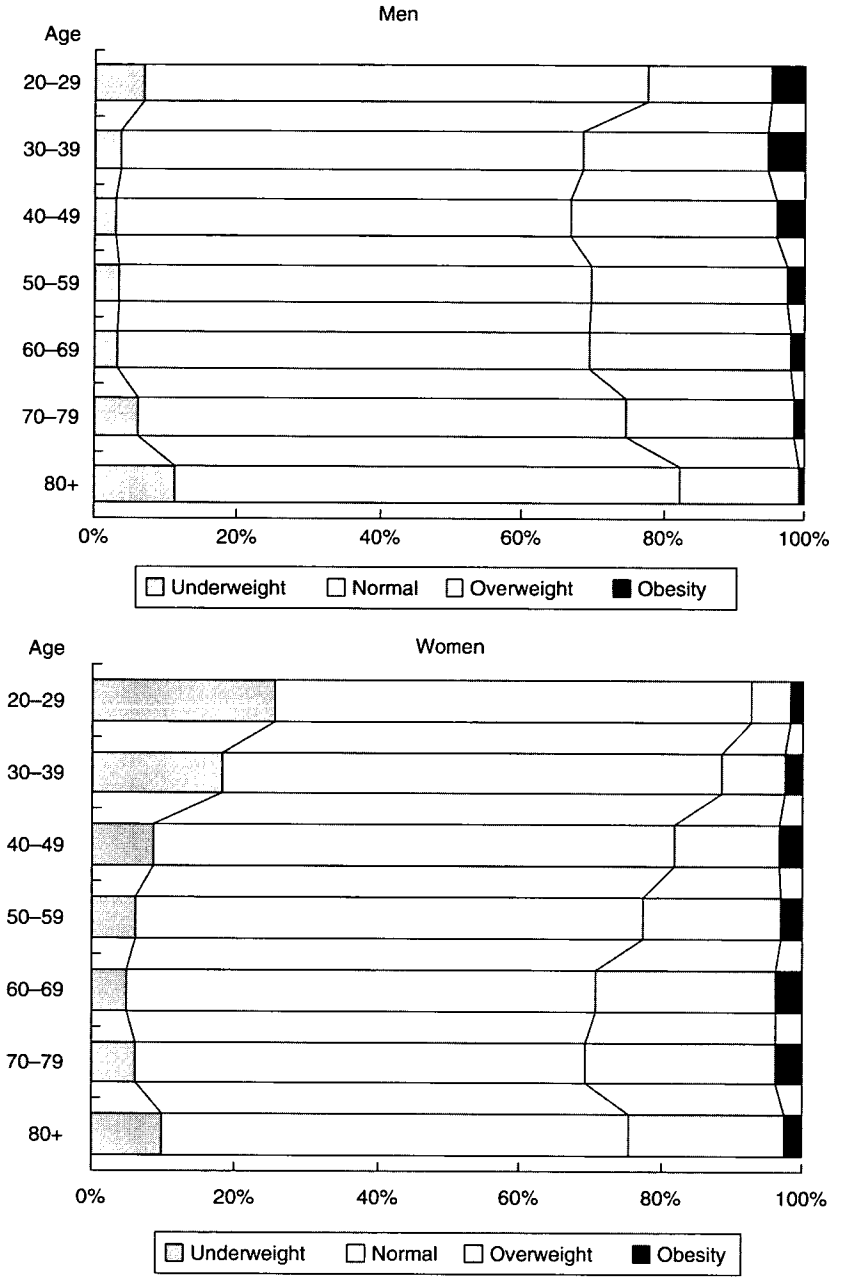

Figure 1 Distribution of BMI. BMI: underweight −18.5; normal 18.6–24.9; overweight 25.0–29.9; obesity 30.0+

Table 3 presents the regression coefficients of BMI in relation to T-C and LDL-C, which indicate a predicted increase of T-C (mg/dl) or LDL-C (mg/dl) for each unit increase of BMI. The regression coefficients were estimated at significantly positive values, which indicate the BMI-dependent increases of T-C and LDL-C, in both men and women, but the regression coefficients for men were higher than those for women in all age groups. With the highest values at ages 20–29 years in men and at ages 30–39 years in women, the regression coefficients became lower in older age groups until 60 years of age in both men and women.

Table 4 presents the odds ratios for having hypercholesterolaemia according to the T-C value (≥240 mg/dl, 6.20 mmol/l). The estimated odds ratios from the model with normal weight subjects aged 20–29 years as the reference (upper side) confirmed the age- and BMI-dependent increase of the prevalence of hypercholesterolaemia, what was elicited from the descriptive analysis (Table 1). Women had higher odds ratios than men at the same age and BMI groups, because the prevalence of hypercholesterolaemia of the reference was considerably low (2.8%). In order to elucidate the interacting effects of age and BMI on the prevalence of hypercholesterolaemia, the analyses were repeated separately for age groups. The estimated odds ratios (lower side) showed the BMI-dependent increase of the prevalence of hypercholesterolaemia with a tendency to decrease with age until 70 years of age in both men and women.

Table 1 Means and prevalence of hypercholesterolaemia (≥240 mg/dl, 6.20 mmol/l) for total cholesterol

		Men					*Women*				
			Mean ± SD		*Hypercholesterolaemia*			*Mean ± SD*		*Hypercholesterolaemia*	
Age	*BMI*	*n*	*(mg/dl)*	*(mmol/l)*	*n*	*%*	*n*	*(mg/dl)*	*(mmol/l)*	*n*	*%*
All		337690	202.1 ± 35.1	5.22 ± 0.91*,†	46967	13.9¶,**	293918	209.0 ± 36.4	5.40 ± 0.94*,†	56865	19.3¶,**
20–29		26623	181.7 ± 32.1	4.70 ± 0.83†	1273	4.8**	21628	177.6 ± 29.3	4.59 ± 0.76†	644	3.0**
30–39		61332	199.4 ± 35.3	5.15 ± 0.91†	7744	12.6**	36391	186.5 ± 30.9	4.82 ± 0.80†	1925	5.3**
40–49		84272	207.0 ± 35.2	5.35 ± 0.91†	14358	17.0**	64742	201.1 ± 32.8	5.20 ± 0.85†	7680	11.9**
50–59		87597	207.0 ± 34.4	5.35 ± 0.89†	14393	16.4**	80619	222.3 ± 34.7	5.74 ± 0.90†	23541	29.2**
60–69		49105	203.0 ± 33.4	5.25 ± 0.86†	6511	13.3**	54291	222.4 ± 33.4	5.75 ± 0.86†	15491	28.5**
70–79		24083	196.7 ± 33.1	5.08 ± 0.86†	2375	9.9**	30130	215.5 ± 32.4	5.57 ± 0.84†	6540	21.7**
80+		4678	191.0 ± 33.1	4.94 ± 0.86†	313	6.7**	6117	209.5 ± 33.0	5.41 ± 0.85†	1044	17.1**
All	Underweight	13182	184.4 ± 32.9	4.76 ± 0.85†,‡	689	5.2††	27891	194.1 ± 34.6	5.02 ± 0.89†,‡	2853	10.2††
	Normal	222868	199.5 ± 34.3	5.16 ± 0.89†	27115	12.2	203522	208.2 ± 36.1	5.38 ± 0.93†	38042	18.7
	Overweight	90570	209.5 ± 35.1	5.41 ± 0.91§	16790	18.5	53673	218.2 ± 35.4	5.64 ± 0.91§	13837	25.8
	Obesity	11070	213.3 ± 36.5	5.51 ± 0.94§	2373	21.4	8832	217.3 ± 35.7	5.61 ± 0.92§	2133	24.2
20–29	Underweight	1846	166.3 ± 26.3	4.30 ± 0.68‡	14	0.8††	5553	174.3 ± 27.5	4.50 ± 0.71‡	114	2.1††
	Normal	18798	178.3 ± 30.0	4.61 ± 0.78	586	3.1	14465	177.5 ± 28.9	4.59 ± 0.75	401	2.8
	Overweight	4743	194.7 ± 33.9	5.03 ± 0.88	469	9.9	1212	187.0 ± 32.5	4.83 ± 0.84	80	6.6
	Obesity	1236	206.1 ± 37.2	5.33 ± 0.96	204	16.5	398	198.0 ± 38.5	5.12 ± 0.99	49	12.3
30–39	Underweight	2269	179.7 ± 30.2	4.64 ± 0.78‡	73	3.2††	6630	182.1 ± 29.7	4.71 ± 0.77‡	259	3.9††
	Normal	39715	195.0 ± 33.4	5.04 ± 0.86	3803	9.6	25561	185.4 ± 29.9	4.79 ± 0.77	1157	4.5
	Overweight	16164	209.8 ± 36.2	5.42 ± 0.94	3111	19.2	3297	198.1 ± 34.0	5.12 ± 0.88	366	11.1
	Obesity	3184	215.3 ± 37.4	5.56 ± 0.97	757	23.8	903	207.2 ± 37.1	5.35 ± 0.96	143	15.8
40–49	Underweight	2518	188.2 ± 31.7	4.86 ± 0.82‡	129	5.1††	5645	194.9 ± 31.4	5.04 ± 0.81‡	456	8.1††
	Normal	53825	203.9 ± 34.3	5.27 ± 0.89	7898	14.7	47317	199.7 ± 32.1	5.16 ± 0.83	5086	10.7
	Overweight	24687	214.2 ± 35.7	5.53 ± 0.92	5513	22.3	9778	209.0 ± 34.3	5.40 ± 0.89	1726	17.7
	Obesity	3242	217.7 ± 37.1	5.63 ± 0.96	818	25.2	2002	212.9 ± 35.1	5.50 ± 0.91	412	20.6

Table 1 Continued

		Men					*Women*				
			Mean ± SD		*Hypercholesterolaemia*			*Mean ± SD*		*Hypercholesterolaemia*	
Age	*BMI*	*n*	*(mg/dl)*	*(mmol/l)*	*n*	*%*	*n*	*(mg/dl)*	*(mmol/l)*	*n*	*%*
50–59	Underweight	2921	191.6 ± 33.7	4.95 ± 0.87‡	238	8.1††	5010	214.6 ± 33.4	5.55 ± 0.86‡	1109	22.1††
	Normal	58243	205.4 ± 33.9	5.31 ± 0.88	8850	15.2	57315	221.9 ± 34.4	5.73 ± 0.89	16432	28.7
	Overweight	24388	212.2 ± 34.6	5.48 ± 0.89	4912	20.1	15951	225.9 ± 35.5	5.84 ± 0.92	5245	32.9
	Obesity	2045	212.7 ± 34.4	5.50 ± 0.89	393	19.2	2343	225.6 ± 36.3	5.83 ± 0.94	755	32.2
60–69	Underweight	1625	190.3 ± 34.3	4.92 ± 0.89‡	123	7.6††	2611	214.3 ± 33.0	5.54 ± 0.85‡	539	20.6††
	Normal	32459	202.2 ± 33.4	5.22 ± 0.86	4188	12.9	35791	222.3 ± 33.3	5.74 ± 0.86	10176	28.4
	Overweight	14043	206.0 ± 32.9	5.32 ± 0.85	2053	14.6	13933	224.3 ± 33.8	5.80 ± 0.87	4258	30.6
	Obesity	978	206.2 ± 33.6	5.33 ± 0.87	147	15.0	1956	221.4 ± 33.1	5.72 ± 0.86	518	26.5
70–79	Underweight	1476	188.0 ± 33.9	4.86 ± 0.88‡	95	6.4††	1847	207.5 ± 33.1	5.36 ± 0.86‡	306	16.6††
	Normal	16501	196.1 ± 33.1	5.07 ± 0.86	1577	9.6	19049	215.3 ± 32.5	5.56 ± 0.84	4123	21.6
	Overweight	5758	200.2 ± 32.4	5.17 ± 0.84	655	11.4	8153	217.6 ± 32.0	5.62 ± 0.83	1890	23.2
	Obesity	348	203.6 ± 32.6	5.26 ± 0.84	48	13.8	1081	215.5 ± 32.1	5.57 ± 0.83	221	20.4
80+	Underweight	527	180.9 ± 31.8	4.67 ± 0.82‡	17	3.2††	595	201.5 ± 32.0	5.21 ± 0.83‡	70	11.8††
	Normal	3327	191.0 ± 32.9	4.94 ± 0.85	213	6.4	4024	209.3 ± 32.7	5.41 ± 0.84	667	16.6
	Overweight	787	197.1 ± 33.1	5.09 ± 0.86	77	9.8	1349	212.8 ± 33.5	5.50 ± 0.87	272	20.2
	Obesity	37	203.8 ± 37.6	5.27 ± 0.97	6	16.2	149	216.8 ± 33.9	5.60 ± 0.88	35	23.5

BMI: underweight −18.5; normal 18.6–24.9; overweight 25.0–29.9; obesity 30.0+. To convert cholesterol to mmol/l, divide values by 38.7 (240 mg/dl = 6.20 mmol/l).*$p < 0.001$ for age groups by ANOVA. †$p < 0.001$ men vs. women by t-test. §$p < 0.05$ men vs. women by t-test. ‡$p < 0.001$ for BMI groups by ANOVA. ¶$p < 0.001$ for age groups by χ^2-test. **$p < 0.001$ men vs. women by χ^2-test. ††$p < 0.001$ for BMI groups by χ^2-test.

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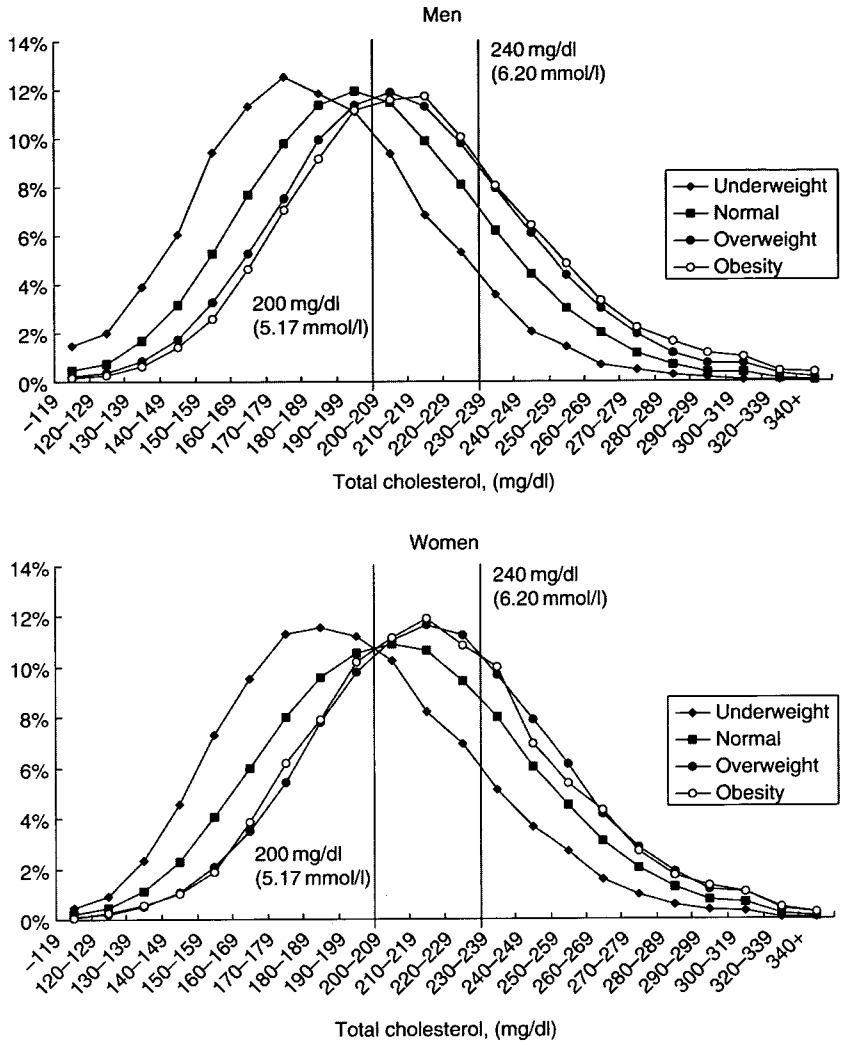

Figure 2 Distribution of total cholesterol by BMI. BMI: underweight −18.5; normal 18.6–24.9; overweight 25.0–29.9; obesity 30.0+. To convert cholesterol to mmol/l, divide values by 38.7

Table 5 presents the odds ratios for having hypercholesterolaemia according to the LDL-C value (≥160 mg/dl, 4.13 mmol/l). The estimated odds ratios were slightly higher than those shown in Table 4, but the two odds ratios indicated similar interacting effects of age and BMI on the prevalence of hypercholesterolaemia.

The prevalence of hypercholesterolaemia according to the T-C value (i.e. percentages of T-C ≥ 240 mg/dl, 6.20 mmol/l) was higher than that according to the LDL-C value (i.e. percentages of LDL-C ≥ 160 mg/dl, 4.13 mmol/l). The differences between the two percentages were more pronounced in underweight subjects, who had higher HDL-C levels than normal, overweight and obesity subjects; the mean (±SD) HDL-C levels in the underweight, normal, overweight and obesity subjects were 65.3 (±16.0), 57.5 (±14.4), 50.8 (±11.9) and 47.4 (±10.4), respectively, in men ($p < 0.001$ with ANOVA) and 71.8 (±15.0), 65.8 (±14.7), 58.8 (±13.1) and 56.1 (±12.0), respectively, in women ($p < 0.001$ with ANOVA).

DISCUSSION

We determined age-, sex- and BMI-specific cholesterol levels of Japanese adults using the 2001 health examination data. The distributions of T-C and LDL-C as well as BMI depended on age and sex. Increased T-C and LDL-C were significantly associated with increased BMI in both men and women. When the impact of BMI on cholesterol levels was evaluated separately for age and sex groups, it was estimated greater in men than in women in all age groups, and greater in younger age groups in both men and women. These results indicate significant effects of age and sex on the relation between BMI and cholesterol. For an accurate estimate of the impact of BMI on cholesterol levels, it is necessary that the effects of age and sex on the relation between BMI and cholesterol should be included in the analysis.

The WHO MONICA Project examined the relationship between age, sex, BMI and hypercholesterolaemia using pooled data from 27 populations aged 25–64 years in 15 countries (14). Multiple logistic regression analysis showed a

Table 2 Means and prevalence of hypercholesterolaemia (≥160 mg/dl, 4.13 mmol/l) for LDL cholesterol

		Men					*Women*				
			Mean ± SD		*Hypercholesterolaemia*			*Mean ± SD*		*Hypercholesterolaemia*	
Age	*BMI*	*n*	*(mg/dl)*	*(mmol/l)*	*n*	*%*	*n*	*(mg/dl)*	*(mmol/l)*	*n*	*%*
All		329724	121.2 ± 31.8	3.13 ± 0.82*,†	36699	11.1§,¶	292999	126.1 ± 32.9	3.26 ± 0.85*,†	43988	15.0§,¶
20–29		26356	105.4 ± 28.7	2.72 ± 0.74†	1078	4.1¶	21612	98.3 ± 25.0	2.54 ± 0.65†	425	2.0¶
30–39		59742	118.9 ± 31.6	3.07 ± 0.82†	5975	10.0¶	36325	105.8 ± 27.0	2.73 ± 0.70†	1314	3.6¶
40–49		81406	124.0 ± 32.3	3.20 ± 0.83†	10603	13.0¶	64574	118.4 ± 29.7	3.06 ± 0.77†	5592	8.7¶
50–59		85259	125.0 ± 32.0	3.23 ± 0.83	11390	13.4¶	80289	137.3 ± 32.1	3.55 ± 0.83	18113	22.6¶
60–69		48377	122.8 ± 30.7	3.17 ± 0.79	5332	11.0¶	54062	138.8 ± 30.6	3.59 ± 0.79	12514	23.1¶
70–79		23917	118.9 ± 29.7	3.07 ± 0.77	2026	8.5¶	30033	133.3 ± 29.4	3.44 ± 0.76	5221	17.4¶
80+		4667	115.7 ± 29.1	2.99 ± 0.75	295	6.3¶	6104	128.7 ± 28.9	3.33 ± 0.75	809	13.3¶
All	Underweight	13080	102.4 ± 29.7	2.65 ± 0.77†,‡	457	3.5¶,**	27872	109.2 ± 29.4	2.82 ± 0.76†,‡	1585	5.7¶,**
	Normal	219122	119.1 ± 31.3	3.08 ± 0.81†	21578	9.8¶	203082	125.2 ± 32.5	3.24 ± 0.84†	28918	14.2¶
	Overweight	87076	128.1 ± 31.4	3.31 ± 0.81†	12891	14.8¶	53309	136.5 ± 32.0	3.53 ± 0.83†	11660	21.9¶
	Obesity	10446	130.8 ± 32.5	3.38 ± 0.84†	1773	17.0¶	8736	136.1 ± 31.8	3.52 ± 0.82†	1825	20.9¶
20–29	Underweight	1844	90.9 ± 22.8	2.35 ± 0.59‡	13	0.7**	5552	93.7 ± 22.7	2.42 ± 0.59‡	61	1.1**
	Normal	18695	102.7 ± 26.9	2.65 ± 0.70	510	2.7	14463	98.2 ± 24.4	2.54 ± 0.63	240	1.7
	Overweight	4632	116.9 ± 30.3	3.02 ± 0.78	382	8.2	1207	111.8 ± 29.0	2.89 ± 0.75	75	6.2
	Obesity	1185	126.7 ± 33.6	3.27 ± 0.87	173	14.6	390	121.6 ± 33.6	3.14 ± 0.87	49	12.6
30–39	Underweight	2257	99.4 ± 27.6	2.57 ± 0.71‡	52	2.3**	6627	99.3 ± 24.7	2.57 ± 0.64‡	121	1.8**
	Normal	39106	115.5 ± 30.3	2.98 ± 0.78	3071	7.9	25538	104.9 ± 25.9	2.71 ± 0.67	764	3.0
	Overweight	15422	127.9 ± 31.8	3.30 ± 0.82	2304	14.9	3268	119.9 ± 29.8	3.10 ± 0.77	311	9.5
	Obesity	2957	132.2 ± 33.1	3.42 ± 0.86	548	18.5	892	128.2 ± 32.2	3.31 ± 0.83	118	13.2
40–49	Underweight	2485	103.5 ± 30.7	2.67 ± 0.79‡	95	3.8**	5642	108.4 ± 27.0	2.80 ± 0.70‡	230	4.1**
	Normal	52524	121.5 ± 31.7	3.14 ± 0.82	5974	11.4	47241	116.8 ± 28.9	3.02 ± 0.75	3562	7.5
	Overweight	23377	130.5 ± 32.2	3.37 ± 0.83	3981	17.0	9708	128.8 ± 30.9	3.33 ± 0.80	1439	14.8
	Obesity	3020	133.2 ± 32.6	3.44 ± 0.84	553	18.3	1983	133.2 ± 30.9	3.44 ± 0.80	361	18.2

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50–59	Underweight	2878	106.0 ± 32.2	2.74 ± 0.83‡	152	5.3**	5003	125.0 ± 29.8	3.23 ± 0.77‡	624	12.5**
	Normal	56969	123.6 ± 31.7	3.19 ± 0.82	7078	12.4	57141	136.6 ± 31.8	3.53 ± 0.82	12419	21.7
	Overweight	23459	130.2 ± 31.4	3.36 ± 0.81	3826	16.3	15835	142.9 ± 32.5	3.69 ± 0.84	4431	28.0
	Obesity	1953	130.8 ± 31.8	3.38 ± 0.82	334	17.1	2310	142.9 ± 32.9	3.69 ± 0.85	639	27.7
60–69	Underweight	1618	107.3 ± 30.6	2.77 ± 0.79‡	71	4.4**	2608	126.7 ± 29.5	3.27 ± 0.76‡	324	12.4**
	Normal	32098	121.9 ± 30.7	3.15 ± 0.79	3420	10.7	35686	138.6 ± 30.4	3.58 ± 0.79	8142	22.8
	Overweight	13711	126.6 ± 29.9	3.27 ± 0.77	1722	12.6	13827	141.7 ± 30.9	3.66 ± 0.80	3614	26.1
	Obesity	950	125.4 ± 30.4	3.24 ± 0.79	119	12.5	1941	138.5 ± 30.3	3.58 ± 0.78	434	22.4
70–79	Underweight	1471	106.7 ± 29.5	2.76 ± 0.76‡	64	4.4**	1845	123.1 ± 28.6	3.18 ± 0.74‡	187	10.1**
	Normal	16408	118.3 ± 29.5	3.06 ± 0.76	1313	8.0	18995	133.2 ± 29.3	3.44 ± 0.76	3265	17.2
	Overweight	5694	123.3 ± 29.3	3.19 ± 0.76	610	10.7	8119	135.8 ± 29.2	3.51 ± 0.75	1570	19.3
	Obesity	344	126.6 ± 28.2	3.27 ± 0.73	39	11.3	1074	134.1 ± 29.3	3.47 ± 0.76	199	18.5
80+	Underweight	527	104.0 ± 26.8	2.69 ± 0.69‡	10	1.9**	595	119.2 ± 26.8	3.08 ± 0.69‡	38	6.4**
	Normal	3322	115.7 ± 28.8	2.99 ± 0.74	212	6.4	4018	128.7 ± 28.6	3.33 ± 0.74	526	13.1
	Overweight	781	123.1 ± 29.2	3.18 ± 0.75	66	8.5	1345	132.3 ± 29.6	3.42 ± 0.76	220	16.4
	Obesity	37	127.2 ± 33.3	3.29 ± 0.86	7	18.9	146	133.9 ± 28.9	3.46 ± 0.75	25	17.1

BMI: underweight –18.5; normal 18.6–24.9; overweight 25.0–29.9; obesity 30.0+. To convert cholesterol to mmol/l, divide values by 38.7 (160 mg/dl = 4.13 mmol/l). *p < 0.001 for age groups by ANOVA. †p < 0.001 men vs. women by *t*-test. ‡p < 0.001 for BMI groups by ANOVA. §p < 0.001 for age groups by χ^2-test. ¶p < 0.001 men vs. women by χ^2-test. **p < 0.001 for BMI groups by χ^2-test.

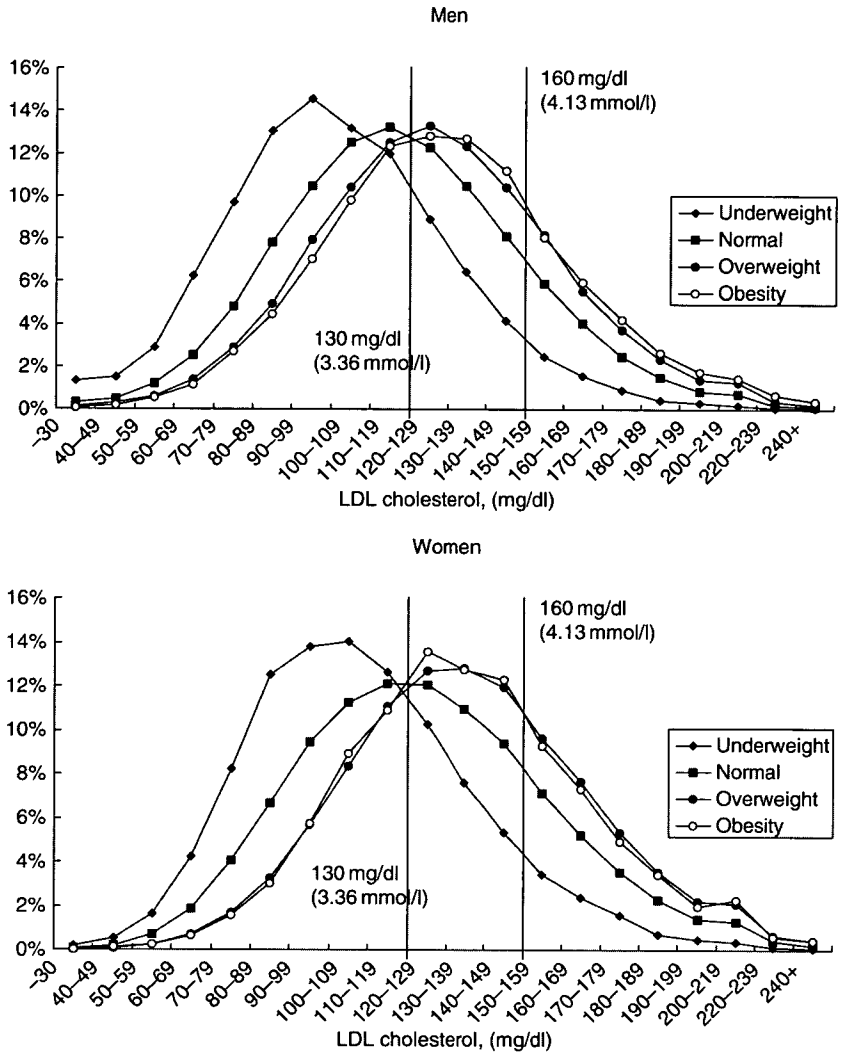

Figure 3 Distribution of LDL cholesterol by BMI. BMI: underweight −18.5; normal 18.6–24.9; overweight 25.0–29.9; obesity 30.0+. To convert cholesterol to mmol/l, divide values by 38.7

Table 3 Regression coefficients (β) with 95% confidence intervals (CIs) of BMI in relation to total cholesterol and LDL cholesterol

		Men	*Women*
	Age	*β (95% CI)*	*β (95% CI)*
Total cholesterol	20–29	2.80 (2.70–2.90)	1.30 (1.18–1.42)
	30–39	2.70 (2.60–2.75)	1.70 (1.62–1.80)
	40–49	2.19 (2.12–2.27)	1.48 (1.40–1.55)
	50–59	1.72 (1.64–1.80)	0.89 (0.82–0.96)
	60–69	1.21 (1.11–1.32)	0.47 (0.38–0.55)
	70–79	1.23 (1.09–1.37)	0.61 (0.50–0.72)
	80+	1.69 (1.37–2.00)	1.01 (0.77–1.26)
LDL cholesterol	20–29	2.52 (2.43–2.61)	1.74 (1.64–1.84)
	30–39	2.37 (2.30–2.44)	2.10 (2.02–2.19)
	40–49	2.09 (2.02–2.16)	2.02 (1.95–2.08)
	50–59	1.86 (1.79–1.94)	1.43 (1.36–1.49)
	60–69	1.48 (1.38–1.57)	0.79 (0.71–0.87)
	70–79	1.58 (1.46–1.71)	0.79 (0.69–0.89)
	80+	1.98 (1.70–2.25)	1.08 (0.87–1.29)

Regression coefficients indicate a predicted increase of total cholesterol (mg/dl) or LDL cholesterol (mg/dl) for each unit increase of BMI.

Table 4 Odds ratios (ORs) with 95% confidence intervals (CIs) for having hypercholesterolaemia (TC ≥ 240 mg/dl, 6.20 mmol/l)

	Men				*Women*			
	Underweight	*Normal*	*Overweight*	*Obesity*	*Underweight*	*Normal*	*Overweight*	*Obesity*
Age	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*
20–29	0.24	1.00	3.41	6.14	0.74	1.00	2.48	4.92
	(0.14–0.41)	(reference)	(3.01–3.87)	(5.18–7.29)	(0.60–0.91)	(reference)	(1.94–3.18)	(3.59–6.75)
30–39	1.03	3.29	7.41	9.69	1.43	1.66	4.38	6.60
	(0.81–1.32)	(3.01–3.60)	(6.76–8.11)	(8.63–10.88)	(1.22–1.67)	(1.48–1.87)	(3.78–5.07)	(5.38–8.10)
40–49	1.68	5.35	8.94	10.49	3.08	4.22	7.52	9.09
	(1.38–2.04)	(4.91–5.82)	(8.19–9.75)	(9.36–11.76)	(2.69–3.54)	(3.81–4.68)	(6.72–8.41)	(7.85–10.53)
50–59	2.76	5.57	7.84	7.39	9.97	14.10	17.18	16.68
	(2.36–3.22)	(5.11–6.06)	(7.18–8.56)	(6.45–8.48)	(8.85–11.24)	(12.74–15.59)	(15.48–19.08)	(14.62–19.02)
60–69	2.55	4.60	5.32	5.50	9.12	13.93	15.44	12.63
	(2.08–3.11)	(4.21–5.03)	(4.84–5.85)	(4.53–6.67)	(7.95–10.47)	(12.58–15.43)	(13.89–17.16)	(10.97–14.55)
70–79	2.14	3.28	3.99	4.97	6.96	9.69	10.58	9.01
	(1.71–2.67)	(2.98–3.62)	(3.55–4.48)	(3.63–6.82)	(5.95–8.16)	(8.72–10.76)	(9.46–11.84)	(7.54–10.77)
80+	1.00	2.13	3.37	6.02	4.68	6.97	8.86	10.77
	(0.64–1.69)	(1.81–2.50)	(2.63–4.32)	(2.50–14.47)	(3.58–6.12)	(6.12–7.93)	(7.50–10.46)	(7.28–15.93)
20–29	0.24	1.00	3.41	6.14	0.74	1.00	2.48	4.93
	(0.14–0.41)	(reference)	(3.01–3.87)	(5.18–7.29)	(0.60–0.91)	(reference)	(1.94–3.18)	(3.60–6.75)
30–39	0.31	1.00	2.25	2.95	0.86	1.00	2.63	3.97
	(0.25–0.40)	(reference)	(2.14–2.37)	(2.70–3.22)	(0.75–0.98)	(reference)	(2.33–2.98)	(3.29–4.79)
40–49	0.31	1.00	1.67	1.96	0.73	1.00	1.78	2.15
	(0.26–0.38)	(reference)	(1.61–1.74)	(1.81–2.13)	(0.66–0.81)	(reference)	(1.68–1.89)	(1.92–2.41)
50–59	0.50	1.00	1.41	1.33	0.71	1.00	1.22	1.18
	(0.43–0.57)	(reference)	(1.35–1.46)	(1.19–1.49)	(0.66–0.76)	(reference)	(1.17–1.27)	(1.08–1.29)
60–69	0.55	1.00	1.16	1.19	0.66	1.00	1.11	0.91
	(0.46–0.67)	(reference)	(1.09–1.22)	(0.99–1.43)	(0.59–0.72)	(reference)	(1.06–1.16)	(0.82–1.01)
70–79	0.65	1.00	1.22	1.51	0.72	1.00	1.09	0.93
	(0.53–0.81)	(reference)	(1.10–1.34)	(1.11–2.06)	(0.63–0.82)	(reference)	(1.03–1.16)	(0.80–1.08)
80+	0.49	1.00	1.59	2.83	0.67	1.00	1.27	1.55
	(0.30–0.81)	(reference)	(1.21–2.08)	(1.17–6.86)	(0.52–0.87)	(reference)	(1.09–1.49)	(1.05–2.28)

ORs with 95% CIs in the upper side were calculated using the model with normal weight subjects aged 20–29 years as the reference. The analyses were repeated separately for age groups, and ORs with 95% CIs in the lower side were calculated using the model with normal weight subjects of the same ages as the reference.

significant negative interaction between age and BMI on the risk of having hypercholesterolaemia (T-C ≥ 6.5 mmol/l) in both men and women. Adjusted odds ratios for having hypercholesterolaemia significantly increased with BMI in men aged 25–44 years and in women aged 25–49 years, but the BMI-dependent increase was smaller (or not significantly observed) in older age groups. The study subjects of the WHO MONICA Project consisted of western populations except for the population of Beijing in China. The prevalence of hypercholesterolaemia as well as overweight and obesity was remarkably higher than that shown in our study. Despite these differences in population, the findings of our study were consistent with the findings of the WHO MONICA Project. The effects of age and sex on the relation between BMI and cholesterol may be of universal application independently of population.

Linear regression analysis showed significant BMI-dependent increases of T-C and LDL-C in both men and women, but the regression coefficients for men were higher than those for women in all age groups. The impact of BMI on T-C and LDL-C levels may be greater in men than in women. Menopausal status is an important determinant of cholesterol level of women (20,21). Although information on menopausal status was not included in the analysis, the result that women had significantly higher T-C and LDL-C levels than men after 50 years of age may be explained by the effect of menopause on cholesterol metabolism rather than the relation between BMI and cholesterol. Compared with western countries, hormone replacement therapy is not so commonly used in Japan (22). Thus, the findings of this study are unlikely to be affected by the use of hormone replacement therapy.

Table 5 Odds ratios (ORs) with 95% confidence intervals (CIs) for having hypercholesterolaemia (LDL ≥ 160 mg/dl, 4.13 mmol/l)

	Men				*Women*			
	Underweight	*Normal*	*Overweight*	*Obesity*	*Underweight*	*Normal*	*Overweight*	*Obesity*
Age	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*
20–29	0.25	1.00	3.21	6.10	0.66	1.00	3.93	8.52
	(0.15–0.44)	(reference)	(2.80–3.68)	(5.07–7.33)	(0.50–0.87)	(reference)	(3.01–5.12)	(6.15–11.79)
30–39	0.84	3.04	6.26	8.11	1.10	1.83	6.23	9.04
	(0.63–1.12)	(2.76–3.34)	(5.68–6.91)	(7.14–9.22)	(0.88–1.37)	(1.58–2.12)	(5.24–7.41)	(7.16–11.39)
40–49	1.42	4.58	7.32	7.99	2.52	4.83	10.31	13.19
	(1.13–1.77)	(4.17–5.02)	(6.66–8.04)	(7.04–9.08)	(2.10–3.03)	(4.24–5.52)	(8.97–11.86)	(11.12–15.65)
50–59	1.99	5.06	6.95	7.36	8.45	16.46	23.03	22.66
	(1.65–2.39)	(4.62–5.54)	(6.32–7.64)	(6.35–8.52)	(7.25–9.84)	(14.46–18.73)	(20.17–26.28)	(19.37–26.51)
60–69	1.64	4.25	5.12	5.11	8.41	17.52	20.97	17.07
	(1.27–2.11)	(3.87–4.68)	(4.63–5.67)	(4.13–6.31)	(7.07–9.99)	(15.38–19.95)	(18.36–23.96)	(14.45–20.16)
70–79	1.62	3.10	4.28	4.56	6.68	12.30	14.21	13.48
	(1.24–2.12)	(2.79–3.44)	(3.79–4.83)	(3.23–6.44)	(5.48–8.15)	(10.77–14.05)	(12.36–16.33)	(11.04–16.46)
80+	0.69	2.43	3.29	8.32	4.04	8.93	11.59	12.20
	(0.37–1.30)	(2.06–2.87)	(2.52–4.30)	(3.64–19.03)	(2.84–5.75)	(7.63–10.45)	(9.56–14.05)	(7.81–19.19)
20–29	0.25	1.00	3.21	6.10	0.66	1.00	3.93	8.52
	(0.15–0.44)	(reference)	(2.80–3.68)	(5.07–7.33)	(0.50–0.87)	(reference)	(3.01–5.12)	(6.15–11.79)
30–39	0.28	1.00	2.06	2.67	0.60	1.00	3.41	4.95
	(0.21–0.37)	(reference)	(1.95–2.18)	(2.42–2.95)	(0.50–0.73)	(reference)	(2.97–3.91)	(4.02–6.08)
40–49	0.31	1.00	1.60	1.75	0.52	1.00	2.13	2.73
	(0.25–0.38)	(reference)	(1.53–1.67)	(1.59–1.92)	(0.46–0.60)	(reference)	(2.00–2.28)	(2.42–3.08)
50–59	0.39	1.00	1.37	1.45	0.51	1.00	1.40	1.38
	(0.33–0.46)	(reference)	(1.32–1.43)	(1.29–1.64)	(0.47–0.56)	(reference)	(1.34–1.46)	(1.25–1.51)
60–69	0.39	1.00	1.20	1.20	0.48	1.00	1.20	0.97
	(0.30–0.49)	(reference)	(1.13–1.28)	(0.99–1.46)	(0.43–0.54)	(reference)	(1.14–1.25)	(0.87–1.09)
70–79	0.52	1.00	1.38	1.47	0.54	1.00	1.16	1.10
	(0.41–0.68)	(reference)	(1.25–1.53)	(1.05–2.06)	(0.47–0.64)	(reference)	(1.08–1.24)	(0.94–1.28)
80+	0.28	1.00	1.35	3.42	0.45	1.00	1.30	1.37
	(0.15–0.54)	(reference)	(1.02–1.81)	(1.49–7.88)	(0.32–0.64)	(reference)	(1.09–1.54)	(0.88–2.13)

ORs with 95% CIs in the upper side were calculated using the model with normal weight subjects aged 20–29 years as the reference. The analyses were repeated separately for age groups, and ORs with 95% CIs in the lower side were calculated using the model with normal weight subjects of the same ages as the reference.

Moreover, the regression coefficients became lower in older age groups until 60 years of age in both men and women. This result was consistent with the result of multiple logistic regression analysis regarding the risk of having hypercholesterolaemia. The impact of BMI on T-C and LDL-C levels may be greater in younger people. Despite the limitation of cross-sectional study, it is worth pointing out that the increased BMI could attribute to the greater part of increased T-C and LDL-C in younger people. Men aged under 40 years and women aged under 50 years had lower prevalence of hypercholesterolaemia but greater impact of BMI on T-C and LDL-C levels than men aged 40–69 years and women aged 50–69 years. Weight reduction should be more strongly recommended to younger people, especially men aged under 40 years and women aged under 50 years, to prevent developing hypercholesterolaemia. On the other hand, older people are more likely to be exposed to comorbidity and menopause. These factors can be a cause of increasing cholesterol levels (1). Drug therapy should effectively be used to improve their hypercholesterolaemia. Even though the impact of BMI on cholesterol levels is smaller in older people, treatment of overweight and obesity should be recommended to reduce their risk of cardiovascular disease.

Compared with previous studies on the relationship between age, sex, BMI and cholesterol (13,14), elderly people aged 70 years or older were included in this study. The regression coefficients showed a tendency to increase with age after 70 years of age. The age groups of 70–79 and 80+ years had lower cholesterol levels and higher prevalence of underweight than middle-aged groups. The increased regression coefficients of the age groups of 70–79 and 80+ years seem to reflect the low cholesterol levels in the underweight subjects rather than

the high cholesterol levels in the overweight and obesity subjects. Low cholesterol may be associated with poor health status and future decline in functional performance in elderly people (23–25). A longitudinal study suggested that increase of non-HDL-C may be beneficial to elderly people without cardiovascular disease (26). At least underweight elderly people should be recommended to gain weight to maintain a desirable cholesterol level.

This study had the following possible limitations. Firstly, the study subjects consisted of participants in health examination. Patients with an advanced disease were excluded because they had few opportunities to receive a health examination in community or worksite. However, the objective of this study was to examine the effects of age and sex on the relation between BMI and cholesterol in community-living population. Indeed the findings of this study should be generalised carefully, but they may be applicable to at least community-living population. Secondly, some confounding factors were not adjusted exactly. Thyroid disease, nephrotic syndrome and liver disease lead to secondary dyslipidaemia (1). Lifestyle habits contribute to changing cholesterol levels (1,4,11,27,28). The relation between BMI and cholesterol is likely to be affected by underlying disease and lifestyle habits to some extent. Finally, the cross-sectional design makes it difficult to determine the causal relation between BMI and cholesterol. Further studies may be required to address the question what extent of increased cholesterol is attributable to increased BMI in a follow-up design.

Despite these limitations, a main advantage of this study is the large number of study subjects with a wide age range. Japanese population has lower cholesterol levels and lower prevalence of overweight and obesity, and correspondingly lower incidence of coronary heart disease than western population (4,11). Generally speaking, it is uncertain whether the findings in western population are applicable to Japanese population. The findings of this study provide valuable information on the relation between BMI and cholesterol in Japanese population.

CONCLUSION

Analysis of the 2001 health examination data revealed significant effects of age and sex on the relation between BMI and cholesterol. The impact of BMI on cholesterol levels was estimated greater in men than in women in all age groups, and greater in younger age groups in both men and women. Weight reduction should be more strongly recommended to younger people, especially men aged under 40 years and women aged under 50 years, to prevent developing hypercholesterolaemia.

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