Original Article

Dietary Iodine Intake in the Chinese Population

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Abstract

Objective To evaluate dietary iodine intake and its potential risks among the Chinese population.

Methods Individual dietary iodine intake was calculated using food consumption data multiplying by iodine concentration in foods, table salt and drinking water, followed by summing, and then compared with the corresponding age-specific reference values, including Upper Intake Level (UL) and Recommended Nutrient Intake (RNI).

Results In areas with water iodine concentration (WI) lower than 150 μg/L, 80.8% of residents had iodine intake between the RNI and UL, 5.8% higher than UL, and the remaining (13.4%) lower than RNI if iodized salt was consumed. However, in the uniodized salt consumption scenario, only 1.0% of residents between RNI and UL, 1.4% higher than UL, and a large part of residents (97.6%) lower than RNI. In areas with WI higher than 150 μg/L ,all residents had iodine intake between RNI and UL if iodized salt was consumed, except 10.5% and 24.9% of residents higher than UL in areas with WI at 150-300 μg/L and higher than 300 μg/L respectively. However, in the uniodized salt consumption scenario, only 1.5% and 1.7% of residents had higher iodine intake than UL respectively.

Conclusion The findings suggested that in general, the dietary iodine intake by the Chinese population was appropriate and safe at the present stage. People in areas with WI lower than 150 μg/L were more likely to have iodine deficiency. While people in areas with WI higher than 150 μg/L were more likely to have excessive iodine intake if iodized salt was consumed.

Key words: Iodine; Exposure assessment; Drinking water Iodine; Dietary Iodine Intake

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INTRODUCTION

Iodine is a trace element in human body as an essential nutrient for the synthesis of thyroid hormones[1]. When iodine requirements are not met, thyroid hormone synthesis is impaired, resulting in hypothyroidism and a series of functional and developmental abnormalities termed as "iodine deficiency disorders (IDD)"[2]. On the other hand, excessive iodine intake may also have negative impacts to thyroid[3-5]. Therefore, there is a need to assess population-wide iodine intake from time to time, in order to ensure the proper implementation of the universal salt iodization (USI) program aiming at controlling IDD in China.

China is one of the countries with the most severe iodine deficiency problems. Salt iodization is a worldwide recognized method for the prevention and control of IDD and was found to substantially increase the average iodine intake and consequently improve iodine status to populations[6]. Researches showed that, after the introduction of iodized salt, goiter prevalence rate among children and adolescents worldwide living in goiter-endemic areas decreased by 40%-95%[7]. Since the USI program was triggered in China for the prevention and control of IDD in 1995, the surveillance on iodine status among the population has been implemented, which has

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provided evidence for strategies in adjusting the iodine content in salt. At present, iodine is added to salt at 20-50 mg/kg in the form of potassium iodate[8].

WI is an important factor affecting iodine intake. In China, WI varies significantly in different geographical areas and higher WI areas are often embedded in lower WI areas. Based on WI and regulation of the Chinese Ministry of Health, the national regions were classified into Iodine-deficient Area (<10 μg/L), Iodine-adequate Area (10-150 μg/L) and Iodine-excessive Area (>150 μg/L)[9-10]. According to the results from five large-scale national IDD surveillances conducted in 1995-2005, the amount of iodine added to salt in the China USI program had been adjusted based on the WI in order to avoid excessive iodine status in higher WI areas. However, in recent years, there has been increasing concern on the possibility of excessive iodine intake and the potential health risks due to the national salt iodization strategy, especially among the people living in some coastal areas who believed that they had higher iodine intake from seafood. The aim of the present study was to assess the dietary iodine intake among the population in different areas stratified by WI (<150, 150-300, or ⩾300 μg/L) under the condition of iodized salt or uniodized salt consumption. The consequential health risk and contributions of foods, drinking water and iodized salt to total iodine intake were also investigated.

METHODS

Calculation of Dietary Iodine Intake

Dietary iodine intake was calculated in a deterministic way by multiplying the consumed amount of a dietary source by the iodine level in that source. The main dietary sources of iodine are food, drinking water, and iodized salt. In this study, food includes kelp, laver, sea fish, and other foods (such as grain, vegetables, fruit, aquatic food) and iodine intake was calculated among 63 323 residents in various parts of China.

Data Sources

Food, including salt, consumption data was mainly from the National Nutrition and Health Survey in 2002 and the drinking water consumption was uniformly assumed as the dietary reference intakes in the Chinese population[11]. Iodine concentrations from different food items, drinking water and table salt were derived from the China Food Composition Table[12] (2002 Edition), China IDD surveillance water iodine data (2002) and surveillance data of water iodine in areas with high iodine level[13] as well as China IDD surveillance salt iodine data[14] (2005), respectively.

Stratified Model and Subgroups of Population

The country was divided into three strata according to WI, i. e. <150, 150-300 and ⩾300 μg/L, and salt consumption was divided into two scenarios: iodized salt consumption and uniodized salt consumption. The population was divided into 13 sub-groups (i. e. under 4, 4-6, 7-10, 11-13, 14-17, over 18 years by sex and the pregnant and lactating women). The dietary iodine intake for each subgroup was calculated. In addition, the contributions of all sources of iodine to the total iodine intake in different WI areas were also calculated.

Criteria Used for the Assessment of Iodine Intake

There were several criteria established by international organizations and governments around the world to assess the dietary iodine intake, i e. Estimated Average Requirement (EAR), Recommended Nutrient Intake (RNI), Tolerable Daily Intake (TDI) or Tolerable Upper Intake Level (UL), etc. The Chinese Nutrition Society has developed RNIs and ULs for iodine in different age-specific populations and pregnant and lactating women (Table 1). To analyze the iodine intake status, the total intake in different subpopulations was compared with EAR, RNI and UL and the proportions of population with iodine intake of <EAR, EAR-RNI, RNI-UL, or ⩾ UL were calculated.

Table 1. Reference Intakes for Iodine (μg/d)[15]

Age (Years)	EAR	RNI	UL
<4	-	50	-
4-	-	90	-
7-	-	90	800
11-	-	120	800
14-	-	150	800
18-	120	150	1 000
Pregnant and Lactating Women	120	200	1 000

Note. Ge KY(Editor-in-Chief). An Overview of Nutrition Sciences, 2004 1st Edition.

RESULTS

In Areas with WI < 150 μg/L

Dietary iodine intakes among populations in areas with WI <150 μg/L are shown in Table 2. Under the iodized salt consumption scenario, the average iodine intakes of all age/sex-specific groups were higher than RNI. Among the whole population, 80.8% of individuals had iodine intake between RNI and UL, 5.8% higher than UL, and 13. 4% lower than RNI. Besides, 9.4% adults aged 18 or above (including pregnant and lactating women) had iodine intake below EAR.

Table 2. Mean Dietary Iodine Intakes for Populations in Areas with Water Iodine Concentration <150 μg/L

Age Groups (Years)	Sex	*N*	Iodized Salt Used					Uniodized Salt Used				
			Mean Iodine intake (μg/d)	Distribution (%)				Mean iodine intake (μg/d)	Distribution (%)			
				<RNI		RNI-UL	≥UL		<RNI		RNI-UL	≥UL
2-	Male	669	212. 3	11. 4		88. 6	-	29. 7	97. 9		2. 1	-
	Female	519	321. 7	7. 5		92. 5	-	133. 0	95. 4		4. 6	-
4-	Male	1 276	334. 4	13. 5		86. 5	-	109. 3	97. 6		2. 4	-
	Female	1 109	368. 7	12. 8		87. 2	-	140. 6	97. 4		2. 6	-
7-	Male	2 144	404. 9	9. 8		85. 3	4. 9	131. 3	97. 7		1. 1	1. 2
	Female	1 883	390. 6	9. 9		85. 9	4. 2	128. 0	97. 5		0. 9	1. 6
11-	Male	1 870	453. 5	10. 4		82. 7	6. 9	122. 3	97. 9		0. 7	1. 3
	Female	1 662	436. 2	13. 6		80. 7	5. 7	130. 1	98. 4		0. 5	1. 1
14-	Male	1 508	525. 4	13. 9		76. 7	9. 5	161. 2	97. 8		0. 7	1. 5
	Female	1 310	466. 2	16. 9		76. 0	7. 0	139. 9	97. 8		0. 8	1. 4
				<EAR	EAR-RNI	RNI-UL	≥UL		<EAR	EAR-RNI	RNI-UL	≥UL
18-	Male	22 860	588. 0	8. 1	3. 5	81. 4	7. 0	182. 0	97. 2	0. 2	0. 9	1. 6
	Female	25 663	520. 5	10. 7	5. 1	78. 9	5. 2	177. 0	97. 4	0. 2	0. 9	1. 5
Pregnant women and Lactating women		850	704. 7	6. 9	8.4	78. 4	6. 4	298. 1	97. 5	0. 2	1. 2	1. 1
Mean		–	–	13. 4		80. 8	5. 8	–	97. 6		1. 0	1. 4

It was found that, under the uniodized salt consumption scenario, the proportion of the individuals with iodine intakes between RNI and UL was only 1.0% (1.4% ≥UL and 97. 6% <RNI). Besides, the iodine intakes in 97.4% of adults with 18+ years of age (including pregnant and lactating women) were below EAR.

In Areas with WI 150-300 μg/L

Table 3 showed dietary iodine intakes among populations from areas with WI between 150 and 300 μg/L. Under the iodized salt consumption scenario, the mean dietary iodine intakes in all age/sex-specific groups from these areas were higher than those from areas with WI<150μg/L. Among the whole population, 89.5% of individuals had iodine intake between RNI and UL and the remaining (10.5%) higher than UL.

It can also be found that, under the uniodized

Table 3. Mean Dietary Iodine Intakes for Populations in Areas with Water Iodine Concentration between 150 and 300 μg/L

Age Groups (Years)	Sex	*N*	Iodized Salt Used			Uniodized Salt Used		
			Mean Iodine intake (μg/d)	Distribution (%)		Mean Iodine intake (μg/d)	Distribution (%)	
				RNI-UL	≥UL		RNI-UL	≥UL
2-	Male	669	373. 3	100. 0	-	190. 6	100. 0	-
	Female	519	482. 7	100. 0	-	294. 0	100. 0	-
4-	Male	1 276	514. 3	100. 0	-	289. 2	100. 0	-
	Female	1 109	548. 6	100. 0	-	320. 5	100. 0	-
7-	Male	2 144	604. 8	91. 4	8. 6	331. 2	98. 5	1. 5
	Female	1 883	590. 5	91. 5	8. 5	327. 9	98. 2	1. 8
11-	Male	1 870	693. 4	85. 2	14. 8	362. 1	98. 5	1. 5
	Female	1 662	676. 1	87. 1	12. 9	369. 9	98. 9	1. 1
14-	Male	1 508	765. 2	79. 6	20. 4	401. 0	98. 3	1. 7
	Female	1 310	706. 1	83. 7	16. 3	379. 8	98. 5	1. 5

(Continued)

Age Groups (Years)	Sex	N	Iodized Salt Used			Uniodized Salt Used		
			Mean Iodine intake (μg/d)	Distribution (%)		Mean Iodine intake (μg/d)	Distribution (%)	
				RNI-UL	≥UL		RNI-UL	≥UL
18-	Male	22 860	827. 8	87. 5	12. 5	421. 9	98. 3	1. 7
	Female	25 663	760. 3	90. 9	9. 1	416. 9	98. 4	1. 6
Pregnant Women and Lactating Women		850	944. 6	87. 3	12. 7	538. 0	98. 7	1. 3
Mean		–	–	89. 5	10. 5	–	98. 5	1. 5

salt consumption scenario, the mean dietary iodine intakes among all age/sex-specific groups were above RNI. The proportion of the individuals with iodine intakes between RNI and UL was 98. 5% (the remaining 1.5% ≥UL).

In Areas with WI ≥300μg/L

Table 4 showed the mean dietary iodine intakes among populations from areas with WI ≥300μg/L. Under the iodized salt consumption scenario, the mean iodine intakes among males older than 7 years and females older than 11 years (including pregnant and lactating women) were above UL and the mean iodine intakes for other age groups stayed between RNI and UL. Among all the population, 75.1% of individuals had iodine intake between RNI and UL, with the remaining 24. 9% higher than UL.

It was also found that, under the uniodized salt consumption scenario, the mean dietary iodine intakes in all population groups were between RNI and UL. Among all the population, 98.3% of individuals had iodine intake between RNI and UL, with the remaining 1.7% higher than UL.

Table 4 Mean Dietary Iodine Intakes for Populations in Areas with Water Iodine Concentration in Water ≥300 μg/L

Age Groups (Years)	Sex	N	Iodized Table Salt Used			Uniodized Table Salt Used		
			Mean Iodine intake (μg/d)	Distribution (%)		Mean Iodine intake (μg/d)	Distribution (%)	
				RNI-UL	≥UL		RNI-UL	≥UL
2-	Male	669	537	100. 0	-	354. 3	100. 0	-
	Female	519	646. 4	100. 0	-	457. 7	100. 0	-
4-	Male	1 276	698. 5	100. 0	-	473. 4	100. 0	-
	Female	1 109	732. 8	100. 0	-	504. 7	100. 0	-
7-	Male	2 144	809. 5	77. 8	22. 2	535. 9	98. 5	1. 5
	Female	1 883	795. 2	78. 1	21. 9	532. 6	98. 2	1. 8
11-	Male	1 870	939. 1	53. 7	46. 3	607. 8	98. 3	1. 7
	Female	1 662	921. 8	59. 1	40. 9	615. 6	98. 6	1. 4
14-	Male	1 508	1 010. 9	46. 5	53. 5	646. 7	98. 1	1. 9
	Female	1 310	951. 8	55. 3	44. 7	625. 5	98. 2	1. 8
18-	Male	22 860	1 073. 5	71. 9	28. 1	667. 6	98. 2	1. 8
	Female	25 663	1 006	79. 5	20. 5	662. 6	98. 2	1. 8
Pregnant Women and Lactating Women		850	1 190. 3	71. 5	28. 5	783. 7	98. 5	1. 5
Mean		–	–	75. 1	24. 9	–	98. 3	1. 7

Contributions to Total Dietary Iodine Intake from Various Food Items

The contributions of various food items, table salt and drinking water to the total dietary iodine intakes in areas with varied WI concentrations are presented in Figure 1. When iodized salt was consumed, regardless of cooking loss, 84.2% of iodine intake by people in areas with WI concentration <150 μg/L was attributed to iodized salt. The contribution of drinking water raised with the increase of WI, which was about 45.4% and 60.4% in areas of WI in the range of 150-300 μg/L and higher than 300 μg/L, respectively.

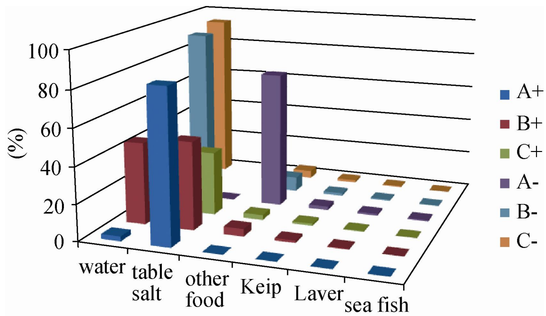

Figure 1. Main sources of food dietary iodine and their contribution rate. *Note:* A^+: WI lower than 150 μg/L and iodized salt is used; B^+: WI between 150 and 300 μg/L and iodized salt is used; C^+: WI higher than 300 μg/L and iodized salt is used; A^-: WI lower than 150 μg/L and uniodized salt is used; B^-: WI between 150 and 300 μg/L and uniodized salt is used; C^-: WI higher than 300 μg/L and uniodized salt is used.

When uniodized table salt was consumed, regardless of cooking loss, 78.7% of iodine intake by people in areas with WI<150 μg/L was attributed to food. However, in areas with WI higher than 150 μg/L, drinking water was the main source of iodine intake. The contribution of drinking water raised with the increase of WI, which was about 89.8% and 93.9% in areas of WI in the range of 150-300 μg/L and higher than 300 μg/L, respectively.

DISCUSSIONS

Albeit in various degrees, most areas in China are water iodine-deficient areas. According to a survey conducted in the 1990s, there were around 720 million people living in water iodine-deficient areas in China, with diagnosed IDD cases in 27 128 villages of 1 807 counties. On the other hand, there were more than 30 millions of people living in water iodine-excess areas based on the data available from a survey conducted in 2005, mainly distributed in the 735 villages and towns of 109 counties (cities, districts) across 9 provinces (regions and municipalities). These water iodine-excessive areas are focally distributed but often embedded in water iodine-deficient or water iodine-adequate areas.

The goal of eliminating endemic iodine-deficiency disease has been achieved since USI policy was widely implemented in many nations including China[16]. On the other hand, there were reports on the adverse effects caused by high amounts of iodine intake[17]. Exposure to excessive iodine occurred *via* food[18], drinking water[19], medication[20], and iodized salt or iodinated oil[21]. Thus, it is important to monitor the iodine intake among various population groups in order to assess both the positive and negative effects of the national USI program.

The present study was mainly focused on the iodine intake using national surveillance data and food composition data as well as IDD surveillance data and it was found that in general, the iodine intake in the Chinese population was at an appropriate and safe level in areas with WI lower than 150 μg/L. At the individual level, the proportion of individuals with iodine intake <RNI was higher than that >UL, indicating that the health risks associated with iodine deficiency outweighed those with iodine excess. This was especially true when uniodized table salt was consumed. Therefore, the results strongly support that the USI Program should be implemented on a continuous basis to further lower the risk of iodine deficiency in population in areas with WI lower than 150 μg/L.

In areas with WI between 150 and 300 μg/L, if uniodized salt was used, the iodine intake in the local people would be maintained at an appropriate and safe level; moreover, 10.5% of the local people would have excessive iodine intake should they use iodized salt. In areas where WI was higher than 300 μg/L, if residents consumed iodized table salt, the mean iodine intakes among males older than 7 years and females older than 11 years (including pregnant and lactating women) were above UL and 24.9% of individuals had iodine intake higher than UL which indicated a high risk of excessive iodine intake. On the other hand, had they consumed uniodized table salt, their relative risk of iodine deficiency was quite low. These results support the current strategy that USI is not applied to areas with high WI in China. But in a few areas where WI is extremely high, even if iodized salt is not used, it is possible that a significant proportion of population may have excessive intakes of iodine. It is recommended that related research should be carried out to assess the long term health impact of excessive intake of iodine from drinking water.

The iodine rich food, such as kelp and laver, was consumed both in low frequency and quantity and contributed only to a very low percentage (1.6%-3.0%) of the dietary iodine intakes regardless of whether the population takes iodized or uniodized salt in areas of varied iodine concentration in water, suggesting that iodine rich food had little effect on the total iodine intake.

Iodine status of the population can be measured by assessing dietary intake or by measuring iodine excretion in the urine. Urinary iodine level in 24-h samples is now widely accepted as one of the best and most cost-effective way to monitor iodine deficiency at community level[22]. According to nationwide survey, the median urinary iodine (MUI) level in the Chinese population was 246.3 µg/L in 2005 after the added iodine in salt was reduced from 20-60 mg/kg to 20-50 mg/kg in 2000. Although it exceeded the appropriate level of MUI, the risk of causing adverse health effects was considered low[23]. In iodine deficiency areas in China in 2009, MUI of children between 8-10 years of age was 192.3 µg/L indicating that the iodine nutritional status of the population in the above areas was appropriate and safe in general. But the percentage of individuals with MUI below 100 µg/L was 21.4%, suggesting that dietary iodine intake were more likely inadequate among these children[24]. In high water iodine areas in 2005, however, the MUI value exceeded 300 µg/L and the proportion of individuals with urinary iodine ⩾300 µg/L reached 74%. It is expected that high MUI will be controlled after the supply of uniodized salt to these high WI areas. In general, the MUI data is in consistent with our findings in dietary iodine intake that the iodine nutritional status in the general Chinese population is at an appropriate and safe level. However, due to the distinct regional disparity in the distribution of iodine concentration in water across the country, there are still population groups with iodine intake below the adequate level as well as population groups with excessive iodine intake.

It should be noted that loss of iodine during cooking is not under consideration in the assessment. On average, iodine loss from salt have been reported up to 20% during cooking[25]. Also, it would be more appropriate if real consumption data of drinking water was used, instead of the assumed recommended drinking water consumption data.

Overall, the iodine nutritional status in the Chinese population is at an appropriate and safe level. Guidance for different localities should be specialized in order to lower the risk of iodine deficiency in population of low WI areas and, at the same time, to avoid the risk of iodine excess for those people living in high WI areas.

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REFERENCES

1. Hetzel BS. The story of iodine deficiency an international challenge in nutrition. Oxford University press, Oxford, 1989; 1-87.
2. WHO, ICCIDD, UNICEF. Assessment of the iodine deficiency disorders and monitoring their elimination. 3rd edition. Geneva: WHO; 2007.
3. World Health Organization. Assessment of Iodine Deficiency Disorders and Monitoring their Elimination. A Guide for Programme Managers. Geneva: WHO. 2001.
4. Teng W, Shan Z, Teng X, et al. Effects of iodine intake on thyroid function in China. N Engl J Med, 354, 2006; 2783-93.
5. Laurberg P, Bulow PI, Knudsen N, et al. Environmental iodine intake affects the type of non-malignant thyroid disease. Thyroid, 2001; 11, 457-69.
6. Vejbjerg P, Knudsen N, Perrild H, et al. Effect of a mandatory iodization program on thyroid gland volume based on individuals' age, gender, and preceding severity of dietary iodine deficiency: a prospective, population-based study. J Clin Endocrinol Metab, 2007; 92, 1397-401.
7. Lowenstein FW. Iodized salt in the prevention of endemic goiter: a world-wide survey of present programs, 1967; 57, 1816-23.
8. GB5461-2000.Edible salt. (In Chinese)
9. GB 16005-1995. Criteria of delimitation for iodine deficiency disorder (IDD) endemic area. (In Chinese)
10. GB/T 19380-2003. Determination and classification of the areas of high water iodine and the endemic areas of odine excess goiter. (In Chinese)
11. Chinese Nutrition Society. Dietary Reference Intakes of Chinese population. China Light Industry Press, 2000; 407. (In Chinese)
12. Yang YX, Wang GY, Pan XG. China food composition tables. Beijing: Beijing Medical University Publishing House. (In Chinese)
13. Liu SJ, Su XH, Yu J, et al. Report on National IDD Surveillance in China (2002). IDD Surveillance in China (2002). Beijing: People's Health Publishing House, 2003, 3-43. (In Chinese)
14. Liu SJ, Su XH, Sun DJ, et al. Report on National IDD Surveillance in China (2005). IDD Surveillance in China 2005. Beijing: People's Health Publishing House, 2005; 3-32. (In Chinese)
15. Ge KY (Editor-in-Chief). An Overview of Nutrition Sciences, 2004 1st Edition. People's Health Publishing House, 138-9. (In Chinese)
16. Delange F, Lecomte P. Iodine supplementation: benefits outweigh risks. Drug Saf, 2000; 22, 89-95.
17. Markou K, Georgopoulos N, Kyriazopoulou V, et al. Iodine-induced hypothyroidism. Thyroid, 2001; 11, 501-10.
18. Konno N, Makita H, Yuri K, et al. Association between dietary iodine intake and prevalence of subclinical hypothyroidism in the coastal regions of Japan. J Clin Endocrinol Metab, 1994; 78, 393-7.
19. Zhao JK, Chen ZP, Maberly GF. Iodine-rich drinking water of natural origin in China. Lancet, 1998; 352, 2024.

20. Martino E, Bartalena L, Bogazzi F, et al. The effects of amiodarone on the thyroid. Endocr Rev, 2001; 22, 240-54.
21. Wolff J. Physiology and pharmacology of iodized oil in goiter prophylaxis. Medicine, 2001; 80, 20-36.
22. WHO/UNICEF/ICCIDD. Assessment of iodine deficiency disorders and monitoring their elimination. A guide for programme managers. 3rd ed.Geneva: WHO; 2007.
23. Liu Y, Liu S, Su XH, et al. Evaluation on the surveillance results of urinary iodine levels of school-age children in China (2005). 2007; 26(4): 438-40. (In Chinese)
24. Notice of the General Office of the Ministry of Health on the Work Status of Surveillance of Iodized Salt in China in 2009 (No. [2010] of the General Office of the Ministry of Health on Disease Control). March 2010. (In Chinese)
25. Chopra IJ. Nature, Sources, and relative biological significance of circulating thyroid hormones. in: Braverman LE, Utiger RD, editors. A Fundamental and Clinical Text. Philadelphia, PA: JB Lippincott Publishing, 1991. 190-203.