Vitamin D levels in relation to low back pain during adolescence

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Running head: low back pain and Vitamin D level in adolescence

This peer-reviewed article has been accepted for publication but not yet copyedited or typeset, and so may be subject to change during the production process. The article is considered published and may be cited using its DOI
10.1017/S0007114520000720
The British Journal of Nutrition is published by Cambridge University Press on behalf of The Nutrition Society

Abstract:
This study aimed to investigate the association between 25-hydroxyvitamin D (25(OH)D) level and Low back pain (LBP) among adolescents while adjusting for potential confounders pertinent to this age group including the weight of school bags, body mass index and physical activity. A cross-sectional study was conducted on randomly selected 760 adolescents in middle schools. Data on LBP and the risk factors for LBP were collected from the parents by self-administered questionnaire and from adolescents by face-to-face interview. Blood samples were tested in an accredited laboratory; and 25(OH)D was measured using liquid chromatography-tandem mass spectrometry. The life-time prevalence and the 6-month prevalence of LBP were 32.28% (95%CI: 28.97-35.73 %) and 21.26% (95%CI:18.40–24.33%), respectively. There was no difference in the geometric mean of 25(OH)D between those with and without LBP in the past six months, 28.50 nmol/L and 30.82 nmol/L, respectively (p= 0.122). There was no association between 25(OH)D and LBP in the univariable or multivariable analysis whether 25(OH)D fitted as a continuous, or as a categorical variable. We found no association between vitamin D level and LBP in adolescents in an area with high prevalence of vitamin D deficiency. Although it is important to have sufficient vitamin D levels during adolescence for several other health benefits, we concluded that vitamin D is not a major determinant for LBP among adolescents in our setting.

Keywords: Low back pain, vitamin D, adolescents, school bag, school-aged children

Introduction:

Low back pain (LBP) is a major public health problem that affects all age groups in high-income, middle-income and low-income countries[1]. It has enormous economic impact on patients, governments and healthcare services[2]. Life-time prevalence of LBP is 50-80% in adults[3; 4; 5] while the prevalence in children usually becomes similar to that in adults by the age of 15-18 years[6; 7; 8; 9]. Additionally, LBP is a major contributor to years lived with disability[10]. In adolescents, LBP is a major cause of school absenteeism and loss of educability[11; 12; 13]. LBP in childhood and adolescence is also a significant risk factor for LBP in adulthood, which highlights the importance of prevention at an early age[14].

The underlying causes of non-specific LBP are poorly understood in all age groups, and studies on risk factors associated with LBP have reported controversial results[10]. Having LBP during childhood or adolescence has been consistently reported to be a risk factor for LBP in adulthood[15; 16], while all other factors show weak or inconsistent association[17; 18; 19]. Recently, vitamin D deficiency has been proposed to be a predisposing factor for LBP, particularly in adults. This has attracted huge attention because vitamin D supplementation would potentially be an easy preventive intervention. Although there is no definitive mechanism to explain how vitamin D levels can influence LBP, there are several plausible mechanisms through which vitamin D deficiency may increase the risk of LBP. First, vitamin D deficiency may have proinflammatory effect, which may contribute to LBP[20]. This is supported by several studies which demonstrated that vitamin D supplementation reduces inflammatory markers[21; 22]. Second, vitamin D levels may modulate sensory neuron excitability[23; 24] and influence muscle strength[25; 26], which could both be related to LBP. Finally, low vitamin D levels decrease the uptake of calcium and reduce bone mineralization (osteomalacia or osteoporosis), which may potentially lead to back pain[27].

Several epidemiological studies have attempted to establish the association between vitamin D and LBP and reported conflicting results. A recent literature review of 19 previous studies (11 cross-sectional studies and 8 case-control studies) reported a significant association between vitamin D deficiency and LBP; pooled odds ratio 1.6 (95%CI: 1.20-2.12)[17]. However, when the analysis was stratified by gender and age, the association was not significant in men and was

stronger among women < 60 years with no association in women ≥ 60 years. In fact, authors reported that the association was confined to only studies from Middle-Eastern/Mediterranean region attributing this to climatic and cultural factors. After this review, another nested case-control study showed no association between vitamin D status and the risk of LBP[28] and another review showed high prevalence of hypovitaminosis D in patients with LBP[29]. A recent review of randomized controlled trials that aimed to investigate the impact of vitamin D supplement on non-specific LBP or LBP resulting from osteoporosis showed that vitamin D supplementation is no more effective than placebo[27] and a major Cochrane database systematic review has precluded a large beneficial effect of vitamin D in the treatment of painful conditions[30]. Despite these findings, a recent review showed that vitamin D supplementation is effective in reducing the pain score in chronic widespread pain[31].

Most of the studies included in the literature are confined to adult population and there is paucity of data on adolescents' population. Adolescence is a period of growth, hence LBP in this age group may have a different risk profile and pathways from that in adulthood. Particular covariates have to be taken into account at this age group, and therefore results from studies on adults cannot be directly extrapolated to adolescents. As an example, the association between LBP and the weight of school bag has been under a continuous debate [32] but hardly considered in the previous studies. Heavy weight carried in school bags can distort the natural spinal curvature in the middle and lower back causing muscle strain and irritation to the spine joints and the rib cage [33]. Furthermore, carrying school bag with center of gravity (CG) positioned at thoracic vertebrae region as T7 causes significant forward displacement in body posture [34], while carrying school bag with CG at the lumbar region usually lead to an increase in spinal flexion as well as reductions in pelvic anteversion and rectus abdominis muscle activity [35]. Previously, from the same dataset we have demonstrated that vitamin D deficiency is very common in adolescents in Kuwait[36]. In this study we aimed to investigate the association between vitamin D level and LBP among adolescents in public middle schools in Kuwait while adjusting for obesity, physical activity, and the weight of school bags.

Methods:

Participants:

Data were collected within a project that aimed to estimate the prevalence of vitamin D deficiency among middle school children (11 -16 years). The details of the project have been described previously[36]. In brief, a nationally representative sample of students was selected from public middle schools in Kuwait using multistage cluster sampling. Each school was given probability to be selected proportionate to its relative size as judged by the number of students in that school compared to the total number of students in the province (probability proportional to size sampling). The participants were selected from 12 public middle schools. A team of investigators drew blood samples and collected data on socio-demographic factors from the parents of selected adolescents through a self-administered questionnaire. Data were also collected on factors related to lifestyle such as physical activity and smoking through face-to-face interviews with the adolescents. Another team of researchers at a later time (minimum of 12 months from the time of blood collection) was formulated to interview the students and collect data on back pain and its related factors. This was conducted on a subgroup of students (N=762). This study including the original project were approved by The Ethics Committee at the Health Sciences Centre, Kuwait University (No: DR/EC/2338) and The Ethics Committee at The Ministry of Health in Kuwait (No: 2015/248). Data collection was initiated only after written informed consent was obtained from the parents and verbal assents from the adolescents.

Collection of blood samples and laboratory methods:

In the original project, five ml of venous blood was drawn by a trained nurse. On the same day, the samples were centrifuged, and the serum was transferred to Eppendorf tubes and stored at -80◦C for analysis. We measured Serum 25-hydroxyvitamin D- 25(OH)D concentration, which is known to be the best marker of vitamin D status that reflect both the amount of vitamin D produced in the skin after sun exposure and the amount consumed in foods[37]. We used liquid chromatography-tandem mass spectrometry (LC-MS/MS) to measure 25(OH)D, which is the gold standard method of vitamin D assessment[38; 39]. This assay has a detection limit of 2 ng/mL for 25(OH)D_3; with the Intra-assay coefficient of variation (CV) of 3.7%, and the Inter-assay CV of 5.3 to 6.0%. Complete blood count (CBC), Parathyroid Hormone (PTH), vitamin B_{12}, Iron, ferritin, transferrin and transferrin saturation were all measured in an accredited clinical

biochemistry laboratory in a teaching hospital, where these tests are routinely conducted under strict quality control. Serum intact Parathyroid hormone (PTH) was assessed using the Access Intact PTH chemiluminescent immunoassay with the Unicel DxI 800 Beckman Coulter analyzer using commercial kit (Cat. # A16972). Serum vitamin B_{12} and Red Blood Cell folate in hemolyzed whole blood were analyzed with Roche commercial kits (Cat. # 04745736 190) and (Cat. # 03253678 122), respectively.

Data collection on low back pain and covariate assessment:

Using a structured questionnaire, three trained data collectors gathered data on LBP through face-to-face interview. The questions on LBP were developed after an extensive literature review of studies that investigated LBP among adolescents. The details of the questionnaire, which has been used in previous studies on LBP in high school students in Kuwait, were published previously[13]. In brief, we collected data on the period prevalence of LBP, including the lifetime, 6-month, and 1-month prevalence. A photo card was used to show each participant the exact location of LBP. Lifetime prevalence was evaluated by the question "Have you ever felt low back pain that lasted a day or longer? (Yes, No, I don't remember)", while 6-month period prevalence was gauged by the question "Have you felt low back pain that lasted a day or longer in the last six months? (Yes, No, I don't remember)". Questions about the frequency of LBP, its impact on daily life activities, treatment needed, absenteeism from school due to LBP, previous back injuries and relatedness of LBP to menstrual cycle (amongst females) were included. A 0-10 Numeric Pain Rating Scale was used to rate the intensity of LBP in past month. Data on depressive symptoms were collected using the Children's Depression Inventory (CDI)[40], which has been translated and adopted in our setting[41].

Although the association between weight of school bags and LBP is under debate, we measured the weight (kg) of every student's bag using a portable digital luggage scale (SAFEWAYR) that was calibrated before each use. We also collected data on the perceived heaviness of school bags by asking the students the question "How would you describe the weight of your school bag? (Light, Normal, Heavy, Too heavy). Data were also collected on the number of school bags a student carries and the use of lockers to reduce the weight of their bags. The weight of each adolescent was measured to the nearest 0.1 kg and the height to the nearest 0.1 cm in a standardized manner using a digital scale after removing shoes and any heavy clothing.

Statistical analysis:

BMI was calculated as weight (Kg) divided by height squared (m^2) and BMI-for-age z-scores were calculated using WHO growth charts. 25(OH) D status was defined according to the Endocrine Society [42] and the Society for Adolescent Health and Medicine [43] as deficiency < 50 nmol/L; insufficiency 50-75 nmol/L; sufficiency≥ 75 nmol/L. The association between 25(OH) D and LBP was assessed using unconditional logistic regression with adjustment for potential confounders. Separate analyses were performed with 25(OH) D fitted as a continuous variable and as categorical variable. We categorized 25(OH) D using acceptable cutoff points[42] or quartiles. First, crude odds ratios were calculated, then variables with $p<0.2$ were introduced sequentially to the model while noting the impact of this on the association between 25(OH) D and LBP. Some studies have suggested that the association between 25(OH) D and LBP is dependent on age and gender[17; 28], we therefore, performed separate tests for the interaction between 25(OH) D and gender as well as age. As a sensitivity analysis, we used stepwise logistic regression to explore if the conclusion on the association between 25(OH) D and LBP would be different with stepwise variables selection. Data analysis was conducted using Stata (StataCorp. 2011. Release 12) and factors that showed $p<0.05$ were deemed to be statistically significant.

Results:

Of 1416 adolescents with 25(OH)D measurement, 762 were interviewed to collect data on LBP and its related factors. The mean (SD) age was 12.26 (0.81) years, and 386 (50.66%) were males. The life-time prevalence of LBP was 32.28% (95% CI: 28.97-35.73 %), which was significantly higher among females compared to males (36.44% vs. 28.24 %; p=0.016). Also, the 6-month prevalence of LBP was 21.26% (95% CI: 18.40–24.33%), which was 24.27% and 18.44% in females and males, respectively (p=0.050). The one-month prevalence was 13.25% (95% CI: 10.93-15.87%) and was also significantly higher among females compared to males (16.27% vs. 10.39%; p=0.017). Among those who reported LBP during the past month, 66.99% sought no treatment, 19.42% used home remedies (e.g. hot packs), 5.83% used analgesics over the counter and 7.77% sought medical treatment from a public or a private clinic. In this group, the pain severity was assessed using 0-10 numeric pain rating scale, which showed mean (SD) of 5.52 (1.63) score. The geometric mean (SD) of 25(OH)D was 30.26 (1.77) nmol/L, which was significantly lower among females compared to males, 22.22 (1.69) nmol/L vs. 40.87 (1.55) nmol/L; $p<0.001$. The prevalence of vitamin D deficiency was 93.88% among females and 66.84% among males, $p<0.001$.

The association between socio-demographic factors and LBP in the past six months are shown in Table 1. In this analysis, we excluded two participants who answered "I don't know" when asked about the LBP during the past six months. Except for gender in which females tended to have higher prevalence of LBP, socio-demographic characteristics were not significantly associated with LBP in univariable analysis. Table 2 shows the association between LBP in the past six months and lifestyle factors such as consumption of food not prepared at home, sleeping hours during weekdays and weekends and physical activity. The association between LBP in the past 6 months and BMI categories as well as factors related to school bags in addition to depression score is depicted in Table 2. In this analysis, sleeping hours during the weekdays (but not weekends) ($P=0.024$) and perceived weight of school bag ($P<0.001$) were associated with LBP in the past six months. Neither the absolute weight of school bag ($P=0.528$) nor the weight of school bag as a percentage of body weight ($P=0.059$) was significantly associated with LBP in the past six months in univariable analysis. However, the weight of school bag as a percentage of body weight became significantly associated with LBP in multivariable analysis (Table 4). The other two factors significantly associated with LBP in univariable analysis were siting posture (on bed, desk, floor, and couch) and depression score. The association between various laboratory measurements and LBP in the past six months is demonstrated in Table 3. None of the laboratory results showed significant association with the LBP during the past six months in univariable analysis. This was evident whether these laboratory measurements were fitted as continuous or categorical variables.

There was no difference in the geometric mean of 25(OH)D between those with and without LBP in the past six months, 28.50 nmol/L and 30.82 nmol/L, respectively ($P= 0.122$). The association between 25(OH)D and LBP during the past six months before and after adjusting for potential confounders is shown in Table 5. There was no association between 25(OH)D and LBP in univariable or multivariable analysis whether 25(OH)D was fitted as a continuous, or as a categorized variable using quartiles or acceptable cutoff points. In this analysis, the interaction between gender and 25(OH)D was not significant in all crude ($P\geq 0.157$) or adjusted ($P\geq 0.651$) analyses. We also used stepwise logistic regression method, in which 25(OH)D was not selected neither in forward nor backward selection. When 25(OH)D was forced in this analysis, it was not significant in any model. Vitamin D bindings protein was measured in a subsample of 404

participants, hence we were able to calculate free vitamin D levels as described by Tsuprykov et al. [44]. There was no significant association between free 25(OH)D and LBP in univariable (P=0.603) or multivariable (P=0.457) analysis. We also repeated the above analysis with LBP in the past month or life-time LBP and found no significant association between 25(OH)D and any of these outcomes. Finally, factors that were significantly associated with LBP in the past six months in multivariable analysis were governorate (province) in which the school was allocated (P=0.039), perceived weight of school bag (P=0.001), weight of school bag as a percentage of the body weight (P=0.017), and sleeping hours during weekdays (P=0.037) (Table 4). Using backward and forward stepwise selection, perceived weight of school bag, age of adolescents and sleeping hours during weekdays were the only significant predictors for LBP in the past six months.

Discussion:

In this study we estimated the prevalence of LBP among adolescents in the middle schools in Kuwait and investigated the association between LBP and vitamin D levels. We found the life-time prevalence of LBP to be 32% while the 6-month prevalence to be 21.26%. There was no association between 25(OH)D levels and LBP in the past six months neither in univariable nor in multivariable analysis. This was evident whether 25(OH)D was fitted as a continuous variable or a categorical variable using acceptable cutoff points or quartiles.

The life-time and the 6-month prevalence of LBP in middle school students were lower than that reported among high school students in Kuwait[13]. This can be explained by the notion that the prevalence of LBP increases with age and reaches that of the adult population at the age of 15-18 years[8; 9]. The prevalence was significantly higher among females compared to males, which is consistent with several other studies[9; 45; 46; 47]. Prevalence of LBP in adolescence varies considerably between different studies with life-time prevalence ranges between 11.60% and 85.56% as reviewed by Calvo-Munoz, et al.[8]. Some of these differences could be attributed to methodological differences, including the variation in LBP definition and the age of the targeted groups.

Although there are several plausible pathways in which low vitamin D levels may contribute to LBP, the findings of epidemiological studies on this issue remain controversial. A literature review[27] showed that most studies were on adult populations or included participants with a

wide age range (adolescents and adults) without sufficient numbers to conduct an age-stratified analysis. In our study, we found no significant association between 25(OH)D levels or 25(OH)D status and LBP in adolescents. Our results are different from the findings of another study that investigated this issue among school-aged children[47]. In this study, the authors reported a lower mean of 25(OH)D among school-aged children with severe LBP (n=45) compared to those with moderate LBP (n=85) and no or minimal LBP (n=120). In their results, however, arithmetic mean may not represent the center of the 25(OH)D distribution (e.g. mean=9.5 ng/mL while SD=4.7 ng/mL in the severe LBP group). Our findings match the results of a pilot study among adolescent male ballet dancers[48] as well as a recent nested case-control study among adults (adults 19-55 years)[28]. Both studies showed no significant association between vitamin D status and the risk of LBP. Furthermore, a recent review of studies (mainly on adult population) concluded that there is an association between vitamin D deficiency and LBP overall[17]. However, age and sex stratified analysis showed the association existed only in women < 60 years with no association in men or in women > 60 years. In fact, the authors found the association to be confined to the Middle East/Mediterranean region, with no association between vitamin D and LBP in the studies outside this region. In another recent review of studies on adult population (30 to 66 years), authors found higher prevalence of hypovitaminosis D in patients with LBP compared to those without LBP[29]. One of the possible explanations for these mixed results of observational epidemiological studies is the difference in the measurement of vitamin D as well as the differences in the definition of LBP. Not only are the results of observational studies conflicting, but also the randomized controlled trials that aimed to investigate the impact of vitamin D supplementation on LBP or musculoskeletal pain in general showed mixed results. A recent review of randomized controlled trials showed that vitamin D supplementation is no more effective than placebo in treatment of non-specific LBP or LBP resulting from osteoporosis[27]. A major Cochrane database systematic review has also precluded a large beneficial effect of vitamin D supplementation in the treatment of painful conditions[30]. Some recent reviews showed no clear benefit of vitamin D supplementation in treatment of chronic nonspecific musculoskeletal pain[49] while other reviews showed that vitamin D supplementation is effective in reducing the pain score in chronic widespread pain[31; 50; 51]. Currently, vitamin D supplementation cannot be considered as an independent treatment for chronic pain[52].

While the lack of association between 25(OH)D and LBP could be genuine in our study, it could be due to the fact that our adolescents were mostly vitamin D deficient (80.2% of the study group were vitamin D deficient and only 4.2% had sufficient vitamin D level). In spite of large study size, the small number of adolescents with sufficient vitamin D level lowered the power of the study to detect small differences in the prevalence of LBP. Power calculation showed that our study has 73% power to detect a difference of 10% in the prevalence of LBP between those with and without vitamin D deficiency at 5% level of significance (two-sided) given that the prevalence of LBP we found in the study was 21%. However, the study will have more than 90% power to detect 15% difference in the prevalence of LBP between those with and without vitamin D deficiency while all other assumptions remain the same. Furthermore, in children or adolescents even if the association between 25(OH)D and LBP vitamin D deficiency exists, low vitamin D level would have less time to exert its influence on the risk of LBP compared to adults. Finally, the proposed mechanism for low vitamin D to increase the risk of LBP through reducing bone mineralization (osteomalacia or osteoporosis), seems less likely during adolescence compared to adulthood. This makes the association between vitamin D levels and LBP more elusive in children and adolescents compared to that in adults.

With respect to other risk factors, a recent literature review on risk factors for LBP in children and adolescents showed inconsistent association between all presumed risk factors and LBP[19]. Recently, the association between the weight of school bag and LBP among school children has attracted huge attention. We have previously reported the importance of the perceived weight of school bag compared to the absolute weight of school bag (or the bag weight as a percentage of body weight) for practical and logical reasons among high school students[13]. In our current study, the perceived weight of school bag was significantly related to LBP in univariable and multivariable analyses. We reiterate our previous recommendation that parents should be encouraged not to allow their children to carry school bags, which their children describe as heavy. Such recommendation would be easy to implement, because it does not require weighing the child or the school bag. This does not mean that the weight of school bag as a percentage of body weight is not important. In our previous study, the weight of school bag as a percentage of the body weight was significantly associated with LBP in univariable analysis but not in multivariable analysis among high school students. In the current study, while the weight of

school bag as a percentage of body weight was not significantly associated with LBP in univariable analysis (p=0.059), it was significant in multivariable analysis (p= 0.017). It is worth noting that the perceived weight of school bag was not correlated with the weight of school bag as a percentage of body weight but was correlated with the absolute weight of school bag. A recent literature review showed the association between backpack weight and LBP to be inconsistent across studies[19] and that the available evidence does not support that school bags weighing >10% of the body weight are associated with higher prevalence of LBP among school children[32].

In our study, physical activity was not significantly associated with LBP neither in univariable nor multivariable analyses. Although we collected data on physical activity by a questionnaire that has been previously validated using accelerometers in high school students (Spearman correlation 0.92; p<0.001 for total steps count, not published), self-reported data on physical activity usually carries large amount of non-differential misclassifications. This could bias the association between physical activity and LBP towards the null, which may explain our findings. Previous studies have suggested U-shaped association between physical activity and LBP in adolescents, where both low and high levels of physical activity are associated with higher risk of LBP[9]. Nevertheless, a recent review of the previous studies showed that the association between sport activities and LBP is controversial, with some studies showing positive association or inverse association or no association[19]. Similarly, BMI was not associated with LBP neither in univariable or multivariable analysis in our study. This is consistent with the current literature review which showed that BMI is not a major determinant of LBP in children and adolescents[19].

To our knowledge this is the largest study that investigated the association between vitamin D levels and LBP among adolescents in the Middle East. We have measured 25(OH)D using LC-MS/MS, which is the gold standard method[38; 39] in an accredited laboratory. We collected data on all potential confounders in this age group including the measurement of the weight of school bags, physical activity, BMI, and depression. In order to draw a robust conclusion, we analyzed the association between 25(OH)D and LBP dealing with 25(OH)D as a continuous variable and as categorical variable using quartiles or acceptable cutoff point. This is an important analytical

aspect because the results of the previous studies on this issue were dependent on how the variables were analyzed[27]. We also calculated free vitamin D and investigated its association with LBP for the first time. Inevitably, data collection on LBP relied on recall, which may have caused nondifferential misclassification in the outcome hence biased our findings towards the null. Finally, we did not collect data on other musculoskeletal conditions that may interfere with LBP such as hypermobility syndrome, connective tissue disorder, and juvenile-onset scoliosis.

In conclusion, we have demonstrated that approximately one third of children in middle schools in Kuwait had experienced LBP in their life-time and one fifth had LBP during the past 6 months. We found no significant association between vitamin D levels and LBP in adolescents in an area with high prevalence of vitamin D deficiency. Although, it is important to have sufficient vitamin D level during childhood and adolescence for several health benefits, we concluded that vitamin D is not a major determinant for LBP among adolescents in our setting. We also concluded that the weight of school bag as a percentage of body weight is associated with LBP in adolescence.

Acknowledgment:

This work was partially funded by Kuwait University, Research Sector (Project No. WF 02/13).

The Authors contribution:

AT study design, data collection, data analysis and wrote the manuscript; AR study design, data collection, data interpretation, and review the paper with significant intellectual input. RS study design, data collection, and review the paper with significant intellectual input, LS study design, data collection, and review the paper with significant intellectual input; AHB data collection, and review the paper with significant intellectual input, SB review the paper with significant intellectual input, MA review the paper with significant intellectual input.

The authors have no financial or personal conflicts of interest to declare.

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Table (1). Association between low back pain during the past six month and socio-demographic factors in 760 adolescents in univariable analysis.

Characteristics	Total	Prevalence of low back pain n (%)	Odds Ratio [95% CI]	P
Gender				
Male	385	71 (18.44)	[Ref.]	0.050
Female	375	91 (24.27)	1.42 [1.00- 2.01]	
Age (year)				
<12	326	61 (18.71)	[Ref.]	0.125
12-	294	63 (21.43)	1.18 [0.80- 1.76]	
≥13	140	38 (27.14)	1.62 [1.02-2.58]	
Nationality				
Kuwaiti	559	120 (21.47)	[Ref.]	0.865
Non-Kuwait	201	42 (20.90)	0.97 [0.65 -1.44]	
School's Governorate				
Capital	123	20 (16.26)	[Ref.]	0.118
Hawally	146	37 (25.34)	1.75 [0.95-3.21]	
Farawanya	93	19 (20.43)	1.32 [0.66-2.65]	
Jahra	80	11 (13.75)	0.82 [0 .37-1.82]	
Mubarak al-Kabeer	86	16 (18.60)	1.18 [0.57-2.42]	
Ahmadi	232	59 (25.43)	1.76 [1.00–3.08]	
Father's Education				
Primary/Intermediate/no formal education	100	22 (22.00)	[Ref.]	0.988
Secondary (high school)	181	37 (20.44)	0.91 [0.50-1.65]	
Diploma	154	33 (21.43)	0.96 [0.52-1.77]	
University & above	310	67 (21.61)	0.97 [0.57-1.68]	
Mother's Education				
Primary/Intermediate/no formal education	77	17 (22.08)	[Ref.]	0.809
Secondary (high school)	161	37 (22.98)	1.05 [0.55-2.02]	
Diploma	165	31 (18.79)	0.82 [0.42-1.59]	
University & above	348	76 (21.84)	0.99 [0.54-1.79]	
Father's Income (Kuwaiti dinars)				
< 500	54	13 (24.07)	[Ref.]	0.660
500 to 1000	174	34 (19.54)	0.76 [0.37 -1.58]	
1001 to 1500	226	50 (22.12)	0.90 [0.44 -1.80]	
1501 to 2000	112	24 (21.62)	0.87 [0.40-1.88]	
More than 2000	101	26 (25.74)	1.09 [0.51 -2.35]	

Do not wish to tell	72	11 (15.49)	0.58	[0.24 -1.42]	
Mother employment					
Housewife	246	50 (20.41)		[Ref.]	0.770
Paid employment	385	82 (21.35)	1.06	[0 .71-1.57]	
Other	118	28 (23.73)	1.21	[0.71-2.05]	
Type of housing					
Rented flat	291	61 (20.96)		[Ref.]	0.204
Rented house	82	11 (13.41)	0.58	[0.29-1.17]	
Owned flat	43	12 (27.91)	1.46	[0.71-3.01]	
Owned house	335	76 (22.75)	1.11	[0.76-1.62]	
Total number of siblings					
≤ two	186	39 (20.97)		[Ref.]	0.938
Three-four	302	64 (21.19)	1.01	[0.65-1.59]	
Five or more	261	58 (22.22)	1.08	[0.68-1.70]	
Passive smoking at home					
No	491	107 (21.79)		[Ref.]	0.846
Yes	255	54 (21.18)	0.96	[0.67 -1.39]	

Table (2): Association between low back pain during the past six month and lifestyle factors, physical activity, body Mass Index and depression score in addition to factors-related to school bag in univariable analysis.

Characteristics	Total	Prevalence of low back pain n (%)	Odds Ratio [95% CI]	P
Times per week consumed breakfast not prepared at home				
Zero	338	74 (21.89)	[Ref.]	0.923
One-two times	314	65 (20.70)	0.93 [0.64-1.36]	
Three-four	57	14 (24.56)	1.16 [0.60-2.23]	
Five or more	34	7 (20.59)	0.92 [0.39-2.20]	
Times per week consumed lunch not prepared at home				
Zero	199	42 (21.11)	[Ref.]	0.742
One-two times	442	96 (21.72)	1.04 [0.69-1.56]	
Three-four	66	17 (25.76)	1.30 [0.68-2.48]	
Five or more	31	5 (16.13)	0.71 [0.26-1.98]	
Times per week consumed dinner not prepared at home				
Zero	86	20 (23.26)	[Ref.]	0.475
One-two times	475	102 (21.47)	0.90 [0.52-1.56]	
Three-four	137	25 (18.25)	0.74 [0.38-1.43]	
Five or more	37	11 (29.73)	1.40 [0.59-3.31]	
Times per week child has breakfast before going to school				
Every day/Five days a week	311	72 (23.15)	[Ref.]	0.701
Three-four days a week	97	20 (20.62)	0.86 [0.49 -1.51]	
One-two days a week	127	23 (18.11)	0 .73 [0.44-1.24]	
Never	216	46 (21.30)	0.90 [0.59-1.36]	
Hours of sleep during weekdays				
<7.5 hours (lower tertile)	221	61 (27.60)	[Ref.]	0.024
7.5 hours to < 9 hours (middle tertile)	273	49 (17.95)	0.57 [0.37 -0.88]	
9 hours or more (higher tertile)	265	52 (19.62)	0.64 [0.42-0.98]	
Hours of sleep during weekend				
<9 hours (lower tertile)	160	37 (23.13)	[Ref.]	0.487
9 hours to < 11 hours (middle tertile)	336	65 (19.35)	0.80 [0.50 -1.26]	
11 or more (middle tertile)	263	60 (22.81)	0.98 [0.62-1.57]	
Time walking to school per week (going and coming equal 2 times)				
None	607	129 (21.25)	[Ref.]	0.702

1 to 8 times	102	24 (23.53)	1.14	[0.69 -1.87]	
Every day	51	9 (17.65)	0.79	[0.38-1.67]	
Time spent on physical activity per week					
Low (lower tertile)	238	45 (18.91)		[Ref.]	0.370
Medium (middle tertile)	255	53 (20.78)	1.12	[0.72-1.75]	
High (higher tertile)	267	64 (23.97)	1.35	[0.88-2.07]	
Body Mass Index categories					
Normal weight	331	66 (19.94)		[Ref.]	0.645
Overweight	165	35 (21.21)	1.08	[0.68-1.71]	
Obese	252	57 (22.62)	1.17	[0.79-1.75]	
Under weight	12	3 (33.33)	2.01	[0.59-6.87]	
Depression score using CDI					
<19 score	582	115 (19.76)		[Ref.]	0.010
≥ 19 Score	110	34 (30.91)	1.81	[1.15-2.86]	
Sitting during study or doing homework on:					
Bed	226	62 (27.43)		[Ref.]	0.014
Desk	315	52 (16.51)	0.52	[0.34-0.79]	
Floor	153	30 (19.61)	0.64	[0.39-1.06]	
Couch	65	17 (26.15)	0.94	[0.50-1.75]	
Perceived weight of school bag					
Light	79	14 (17.72)		[Ref.]	<0.001
Normal	350	48 (13.71)	0.74	[0.38-1.42]	
Heavy	290	84 (28.97)	1.89	[1.01-3.56]	
Very heavy	40	15 (37.50)	2.78	[1.18-6.60]	
Absolut weight of school bag (Kg)					
Low (lower tertile) <5.7 kg	249	53 (21.29)		[Ref.]	0.528
Medium (middle tertile) 5.7 to less than 7.0 kg	255	49 (19.22)	0.88	[0.57-1.36]	
High (higher tertile) ≥ 7.0 kg	253	59 (23.32)	1.12	[0.74-1.71]	
Weight of school bag as % of body weight					
≤10 %	222	52 (23.42)		[Ref.]	0.059
> 10% to < 15%	296	50 (16.89)	0.66	[0.43-1.02]	
≥ 15%	239	59 (24.69)	1.07	[0.70-1.64]	

CDI: Children's Depression Inventory

Table (3): Association between low back pain during the past six month and parathyroid hormone, calcium, vitamin B_{12}, anemia, ferritin and folate in univariable analysis.

Characteristics	Total	Prevalence of low back pain n (%)	Odds Ratio [95% CI]	P
Parathyroid Hormone (nmol/L)	759	-- --	1.02 (0.99- 1.06)	0.184
Calcium				
≥ 2.1 (mmol/L)	739	156 (21.11)	[Ref.]	0.675
<2.1 (mmol/L)	20	5 (25.00)	1.24 [0.44-3.48]	
Vitamin B12				
≥ 148 (pmol/L) sufficient	642	141 (21.96)	[Ref.]	0.810
<148 (pmol/L) deficient	25	6 (24.00)	1.12 [0.44-2.86]	
Anemia as defined by WHO [53]				
No	707	148 (20.99)	[Ref.]	0.436
Yes	55	14 (25.45)	1.28 [0.68 - 2.42]	
Iron	759	-- --	1.00 [0.96-1.03]	0.822
Ferritin				
Normal ≥ 15 ng per mL	548	117 (21.35)	[Ref.]	0.881
Low < 15 ng per mL	211	44 (20.85)	0.97 [0.66 - 1.43]	
Folate	760	-- --	1.00 [1.00-1.00]	0.528

WHO: World Health Organization

Table (4): Factors associated with low back pain during the past six months in multivariable analysis.

Characteristics	Total	Prevalence of low back pain	Odds Ratio [95% CI]	P
		n (%)		
Gender				
Male	385	71 (18.44)	[Ref.]	0.452
Female	375	91 (24.27)	1.18 [0.77- 1.81]	
Age (year)				
<12	326	61 (18.71)	[Ref.]	0.064
12-	294	63 (21.43)	1.38 [0.88-2.17]	
≥13	140	38 (27.14)	1.90 [1.10-3.27]	
School's Governorate				
Capital	123	20 (16.26)	[Ref.]	0.029
Hawally	146	37 (25.34)	2.07 [1.07-4.00]	
Farawanya	93	19 (20.43)	1.14 [0.51-2.51]	
Jahra	80	11 (13.75)	0.64 [0 .26-1.61]	
Mubarak al-Kabeer	86	16 (18.60)	1.20 [0.54-2.68]	
Ahmadi	232	59 (25.43)	1.76 [0.95–3.27]	
Hours of sleep during weekdays				
<7.5 hours (lower tertile)	221	61 (27.60)	[Ref.]	0.037
7.5 hours to < 9 hours (middle tertile)	273	49 (17.95)	0.54 [0.33 -0.87]	
9 hours or more (higher tertile)	265	52 (19.62)	0.64 [0.39-1.04]	
Depression score using CDI				
<19 score	582	115 (19.76)	[Ref.]	0.110
≥ 19 Score	110	34 (30.91)	1.49 [1.91-2.44]	
Sitting during study or doing homework on:				
Bed	226	62 (27.43)	[Ref.]	0.141
Desk	315	52 (16.51)	0.58 [0.36-0.93]	
Floor	153	30 (19.61)	0.80 [0.46-1.41]	
Couch	65	17 (26.15)	0.97 [0.47-2.00]	
Perceived weight of school bag				
Light	79	14 (17.72)	[Ref.]	<0.001
Normal	350	48 (13.71)	0.77 [0.38-1.55]	
Heavy	290	84 (28.97)	1.67 [0.83-3.36]	
Very heavy	40	15 (37.50)	2.61 [0.99-6.83]	
Weight of school bag as % of body weight				
≤10 %	222	52 (23.42)	[Ref.]	0.015
> 10% to < 15%	296	50 (16.89)	0.58 [0.36-0.94]	
≥ 15%	239	59 (24.69)	1.11 [0.68-1.81]	

95%CI: 95% Confidence Interval; CDI: Children's Depression Inventory

Table (5): Association between plasma 25-hydroxyvitamin D and low back pain in the past six month before and after adjusting for potential confounders.

Vitamin D status	Prevalence of low back pain (%)	Crude Odds Ratio [95% CI]	Adjusted [a] Odds Ratio [95% CI]
25(OH) D levels nmol/L	--	0 .99[0.98,1.00]	0.99 [0.98,1.00]
P		0.138	0.316
Q1 (25(OH) D < 21.2 nmol/L) (n=189)	44(23.28)	[Reference]	[Reference]
Q2 (25(OH) D ≥21.2 to < 30.95 nmol/L) (n=190)	46(24.21)	1.05[0.66,1.69]	1.12[0.67,2.02]
Q3 (25(OH) D ≥30.95 to < 45 nmol/L) (n=189)	37(19.58)	0.80[0.49,1.31]	0.83[0.44,1.55]
Q4 (25(OH) D ≥ 45 nmol/L) (n=192)	35(18.23)	0.73[0.45,1.21]	0.79[0.39,1.59]
P		0.421	0.592
Severe deficiency (25(OH) D < 25 nmol/L) (n=264)	62(23.48)	[Reference]	[Reference]
Deficiency (25(OH) D ≥ 25 to < 50 nmol/L) (n= 345)	70(20.29)	0.83[0.56,1.22]	0.78[0.48,1.26]
Insufficiency (25(OH) D ≥ 50 to < 75 nmol/L) ((n=119)	23(19.33)	0.78[0.45,1.34]	0.81[0.40,1.65]
Sufficiency (25(OH) D ≥ 75 nmol/L) (n=32)	7(21.88)	0.91[0.38,2.21]	0.93[0.31,2.77]
P		0.743	0.768

Q1-Q3: quartile one to quartile four; 25(OH) D: 25-Hydroxyvitamin D; [a] adjusted for all variables with p<0.2 including gender, age, school governorate (province), sleep hour during weekdays, perceived weight of school bag, the way of sitting during homework or reading, weight of school bag as % of the body weight, parathyroid hormone and depression score.